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Environment

Water Pollution
Control Branch

Wascana Creek/Qu'Appelle River Bacteriological Water Quality — Summer 1982

July, 1984
WPC 39

Wascana Creek/Qu'Appelle River Bacteriological Water Quality (Summer 1982)

Water Pollution Control Branch

June 18, 1984

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1.0 Introduction

Wascana Creek and the Qu'Appelle River between Lumsden and Craven serve as major sources of water for crop irrigation and for livestock watering during the summer months. During this period these water bodies also provide a source of limited water-based recreation (boating, canoeing). Body contact recreation is not considered to be a significant use.

Wascana Creek also serves as the receiving water body for discharges of treated sewage from the City of Regina. It also serves as the ultimate receptacle for storm waters and drainage waters from the urban area of Regina. Also, the creek and river provide an important water source for wildlife and natural vegetation along their undeveloped reaches. Because of the economic and aesthetic importance of these water bodies the protection of their water quality is essential if they are to be utilized and enjoyed to their fullest potential. With respect to Wascana Creek and to portions of the Qu'Appelle River, there remain some water quality concerns which may impede some water uses such as direct contact recreation and vegetable crop irrigation.

A recent report prepared for the Water Pollution Control Branch (WPCB) of Saskatchewan Environment (Tones 1981) concluded that the observed levels of coliform bacteria in Wascana Creek and in the Qu'Appelle River between the confluence and the Lumsden area exceeded the provincial surface water quality objectives

(Saskatchewan Environment 1977) for vegetable crop irrigation and for direct contact recreation.

Because of the perceived importance of the creek and river as sources of water for vegetable crop irrigation and for livestock watering the Water Pollution Control Branch (WPCB) carried out a survey of residents and licenced water users along these water courses to determine the type of water use, the volumes of water used, and the frequency of water use. Also the WPCB undertook increased bacteriological monitoring of the creek and river during the summer of 1982 in order to obtain a better data base for indicator bacteria levels during the prime irrigation periods (July and August).

The following report provides a summary of activities and observations related to the determination of water use along Wascana Creek and the Qu'Appelle River and provides an assessment of the bacteriological quality of these water bodies during July and August of 1982.

The objectives of this report are:

(a) to describe the types and frequency of water use made by residents along Wascana Creek and Qu'Appelle River;

(b) to describe the bacteriological water quality of these water courses during July/August, 1982 with regard to existing

surface water quality objectives for vegetable crop irrigation and recreational use;

(c) to make recommendations regarding the determination of sources or causes of the perceived bacteriological water quality impairment and of solutions to these perceived impairments;

(d) to comment upon the existing surface water quality objectives regarding indicator bacteria.

2.0 Procedures

2.1 Water User Survey

A telephone survey of water users located along Wascana Creek and Qu'Appelle River was conducted by WPCB staff in December of 1981 in order to determine the extent and type of water use and frequency of water use along these water courses. Details of the survey are described in Appendix 1.

Using a land tenure map for the Rural Municipality of Sherwood to determine ownership of lands along the shoreline of the creek and river, landowners or tenants were contacted by telephone and asked questions with regard to the use each made of surface waters which flowed past their property. For each respondent information concerning land location, type of use, area watered, volume of water used, main periods of use, dates of irrigation termination, and water use licence status was recorded. Additional water use information was obtained for water use licence holders from the files of the Water Rights Branch.

2.2 Bacteriological Water Quality Monitoring

In addition to the routine water quality network monitoring conducted by the Water Pollution Control Branch on the creek and river, an increased monitoring regime was implemented in

the months of July and August of 1982 to correspond to the most significant water use period. The increased monitoring was conducted to provide sufficient data to permit calculation of geometric mean values for the indicator bacteria groups (total and fecal coliforms) in at least five samples collected within a 30-day period as specified in the provincial surface water quality objectives (Saskatchewan Environment 1977).

Table 2.1 provides a summary of the sampling sites and Esquadat station numbers concerning the bacteriological monitoring conducted by the WPCB in July and August of 1982 along Wascana Creek and a portion of the Qu'Appelle River.

The water and effluent samples collected were analyzed by the Provincial Water Laboratory in Regina. The analyses included standard membrane filtration (MF) tests for total and fecal coliforms, and for fecal streptococci. For comparison of analytical procedures, additional analyses for total and fecal coliforms were also carried out on many duplicate samples using standard most-probable-number (MPN) procedures. Fecal streptococci analyses by the MPN procedure are not currently carried out at the Provincial Laboratory.

Figure 2.1 shows the location of the sampling stations along each water course.

Table 2.1

List of bacteriological water quality sampling sites

along Wascana Creek and Qu'Appelle River

Sampling Site	Esquadat Code
Riske's Crossing	00SK05130003
Regina Sewage Treatment Plant Outfall (effluent)	75SK05130001
Sidmar Crossing	00SK05130004
Hungry Hollow	00SK05130005
Old Crossing	00SK05130006
Battered Bridge	00SK05130007
Above Qu'Appelle River	00SK05130008
Above Wascana Creek	00SK05150004
Highway #11	00SK05150005
Market Gardens	00SK05150006

3.0 Results and Discussion

3.1 Water User Survey

A detailed report concerning the results of the December, 1981 water user survey is presented in Appendix 1.

Sixty-two known or potential water users along Wascana Creek and the Qu'Appelle River were identified by the telephone survey and review of Water Rights Branch files. Fifty-nine of these were contacted directly by telephone and questioned about their past, present and intended water use activities. Of the 21 individuals who responded that they no longer used creek or river water for any purpose, nine possessed valid, but apparently unused, water use permits. Two of these nine, however, intended to make use of the water courses in 1982 for purposes of vegetable crop and turf irrigation.

Table 3.1 summarizes the water user information with regard to the type of use made of the water and the number of water users in each water use category. Details of the survey results are presented in Appendix 1.

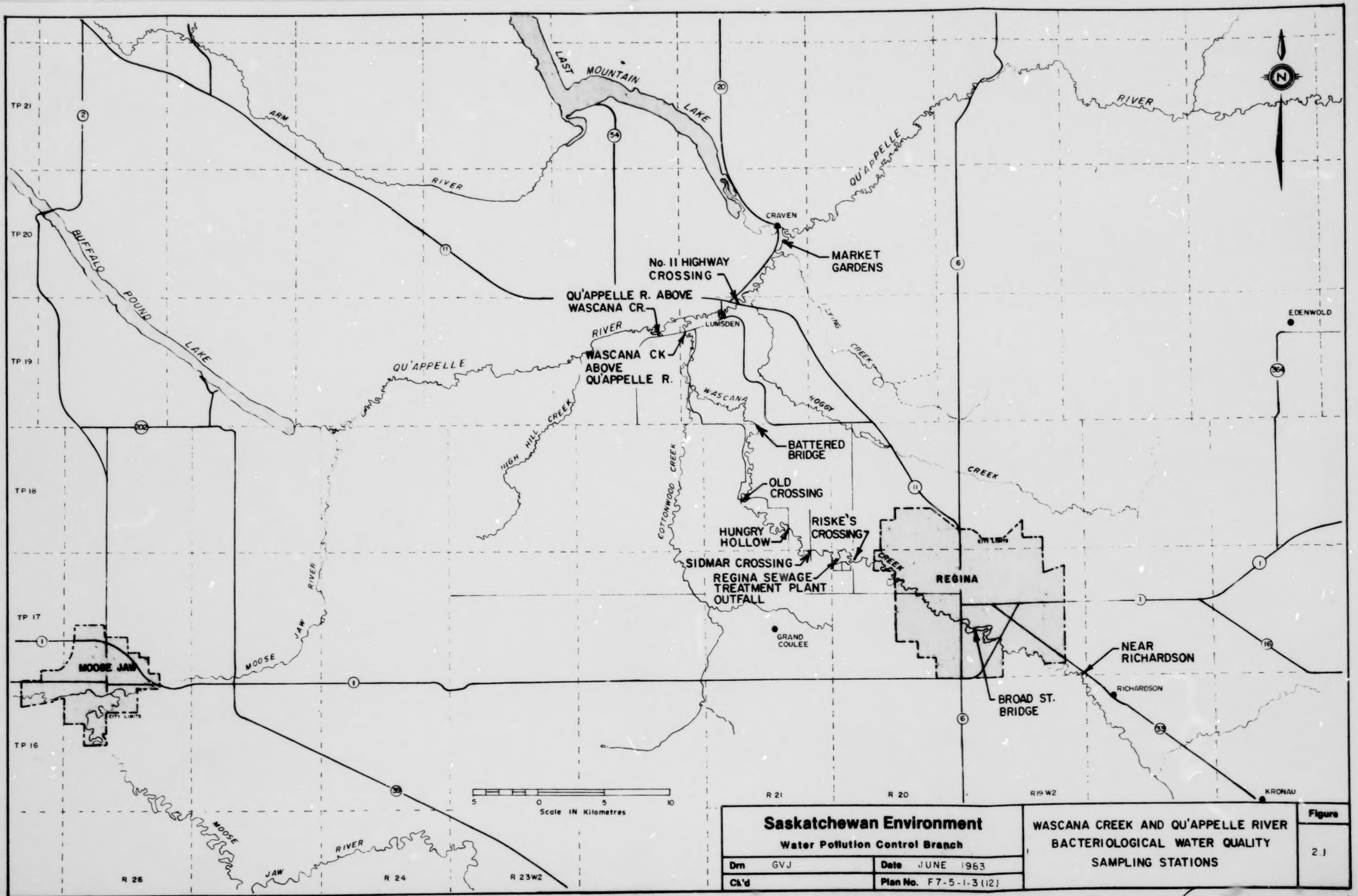
Figure 3.1 shows the location of water users along Wascana Creek and the Qu'Appelle River and provides a legend to indicate the various types of water use at each user location.

Table 3.1

Summary of water users and types of water use along Wascana Creek and Qu'Appelle River

Type of Water Use	Number of Water Users*
Livestock Watering (horses, cattle, sheep)	17
Vegetable Crop Irrigation (domestic and commercial)	28
Forage Crop Irrigation	7
TOTAL:	52

* - Some users used water for more than 1 purpose. For detailed information refer to Appendix 1.



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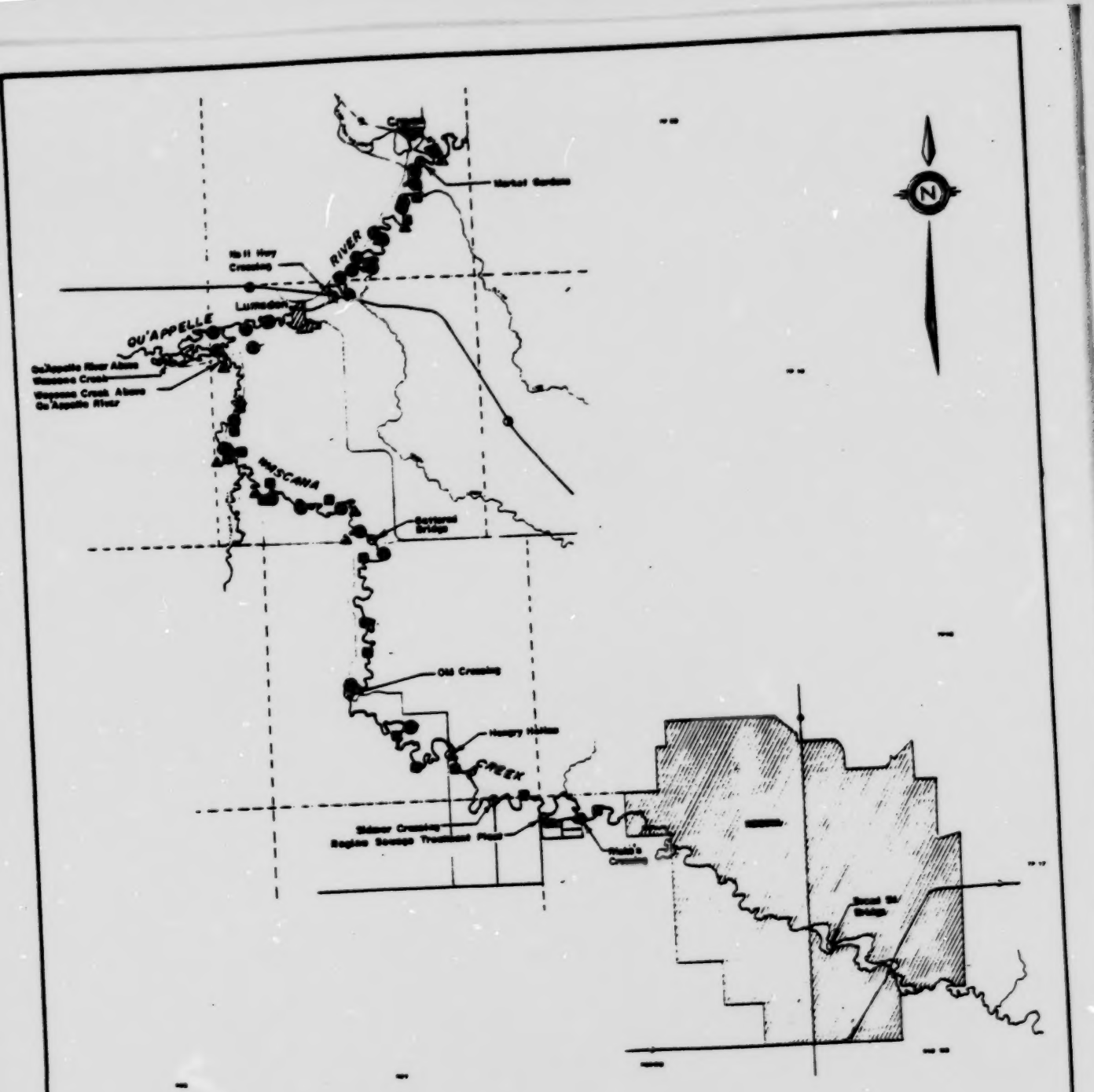
WASCANA CREEK AND QU'APPELLE RIVER BACTERIOLOGICAL WATER QUALITY SAMPLING STATIONS

Figure 2.1



Saskatchewan Environment Water Pollution Control Branch		LOCATION OF WATER USERS AND TYPES OF WATER USE ALONG WASCANA CREEK AND QU'APPELLE RIVER	Figure 3.1
Drn GVJ	Date JUNE 1983		
Ck'd	Plan No. F7-5-1-3(13)		

These findings of the water user survey indicate that vegetable crop irrigation is an important use made of water of the creek and river during the summer months. While some licenced users could irrigate up to predetermined maximum volumes of water, most users indicated that they irrigated their crops when watering was needed. Most vegetable crop irrigators indicated that they terminated their irrigation activities from one day to two weeks prior to crop harvesting.

It is interesting to note that of the 17 water users who utilized the creek or river as sources of water for livestock watering, eight of these watered their livestock from the creek or river year round. In several instances this year-round water use took place at locations just downstream of the Regina Sewage Treatment Plant effluent outfall. Disinfection of the tertiary treated effluent released at this point (Figure 3.1) is not usually practiced for the period of September 30 through to May 15 of the following year.

3.2 Bacteriological Water Quality

In Saskatchewan the bacteriological quality of surface water is assessed using various objectives for indicator bacteria (TC and FC). These bacteriological surface water quality objectives are as follows:

* Parameter	
1. Bacteriology (Coliform Groups)	(a) In waters to be withdrawn for treatment and distribution as a potable supply or used for outdoor recreation other than direct contact, at least 90 per cent of the samples (not less than five samples in any consecutive 30-day period) should have a total coliform density of less than 5,000 per 100 ml and a fecal coliform density of less than 1,000 per 100 ml. (The Maximum Permissible Limit of total coliform organisms in a single sample shall be determined by the Department based on the type and degree of pollution and other local conditions existing within the watershed.)
	(b) In waters used for direct contact recreation or vegetable crop irrigation the geometric mean of not less than five samples taken over not more than a 30-day period should not exceed 1,000 per 100 ml total coliforms, nor 200 per 100 ml fecal coliforms, nor exceed these numbers in more than 20 per cent of the samples examined during any month, nor exceed 2,400 per 100 ml total coliforms on any day.

With respect to crops which are to be eaten raw or with little processing, Ontario water quality objectives suggest a potential health risk if the fecal coliform geometric mean density for a series of a recommended 10 samples per month exceeds 100 FC per 100 ml (Ontario Ministry of the Environment 1978). Water quality in that province is considered to be impaired if the total coliform geometric mean density for a

*Saskatchewan Environment 1975.

series of water samples exceeds 1,000 per 100 ml. The Ontario guidelines further state that water used for irrigation "must be of the best microbiological quality possible, in order to protect the user of the crop from the transmission of disease by this route."

More stringent criteria pertaining to waters used for irrigation (e.g. 2.2 FC per 100 ml) have been implemented in the State of California, apparently because of the perceived potential for disease transmission through vegetable crops irrigated with waters subject to animal/human fecal contamination (V. J. Cabelli, personal communication).

Researchers have noted that emphasis should be placed on sanitary surveys of watersheds (e.g. Cabelli et al 1982, 1983).

Water quality objectives or criteria pertaining to livestock watering have not been established for Saskatchewan and the rationale for such criteria in effect in other jurisdictions is apparently lacking. Ontario formerly recommended an upper limit of 40 enterococci (FS) per 100 ml for livestock watering but current water quality guidelines for that province do not specify criteria involving microbiological variables. In Australia fecal coliform levels are employed to determine the

quality of waters used for livestock watering. Maximum monthly mean densities of FC should be less than 1,000 per 100 ml with no more than 5,000 FC per 100 ml in any one sample (Australian Department of the Environment and Conservation, 1974).

The following presentation primarily relates to a review of bacteriological water quality data for Wascana Creek and the Qu'Appelle River during July and August of 1982. Because of the primary uses of these water bodies being for vegetable crop irrigation and for livestock watering, the emphasis on data analysis and interpretation have necessarily been directed towards the objectives most directly related to these types of water use.

Although geometric mean values for indicator bacteria are generally considered to be the best measure of bacteriological quality during a given time period (usually a 30-day interval), seldom are water samples collected with sufficient frequency to provide an adequate data base for calculating geometric mean values. In Saskatchewan, at least 5 samples over a 30-day period are required for this purpose. For this reason, the frequency of sample collection along the creek and river was increased in July and August of 1982.

The results of bacteriological analyses of water and effluent samples collected along Wascana Creek and the Qu'Appelle River at stations shown in Figure 2.1 are recorded in detail in Appendix 2.

Using data recorded in Appendix 2, geometric mean values were calculated for total and fecal coliforms and for fecal streptococci bacteria observed at various sampling stations on the creek and river in July and August of 1982. These data are presented in Tables 3.2 and 3.3. In some instances, less than 5 sets of data were used to determine the geometric mean values in each month. These exceptions are noted in each table. In all other instances, at least 5 samples were analyzed for each variable by both analytical procedures (MF and MPN).

Membrane filtration data in Tables 3.2 and 3.3 show that the surface water quality objective levels for total coliform (TC) bacteria in water intended for vegetable crop irrigation or for direct contact recreation was exceeded at four stations in July and at seven of the eight stations in August, 1982. The MPN data for this variable revealed only two stations exceeding the geometric mean objective level of 1,000 TC per 100 ml in August (Table 3.3).

During July and August, geometric mean values determined by membrane filtration for fecal coliform (FC) exceeded the surface water quality objective level of 200 FC per 100 ml only at the Regina Sewage Treatment Plant effluent outfall. Three other stations (Riske's Crossing, Above Wascana Creek, and Highway No. 11), however, were found to exceed this objective level only in July, when MPN data was considered (Table 3.2).

Saskatchewan currently does not have a surface water quality objective for fecal streptococci (FS). Geometric mean values for FS ranged from 62 to 298 per 100 ml in July and from 15 to 166 per 100 ml in August at the eight stations.

Water quality criteria in Ontario recommend levels of less than 40 FS per 100 ml for livestock watering and suggest water quality is impaired for direct contact recreational use and for vegetable crop irrigation when geometric mean values for FS exceed 20 per 100 ml (Ontario Ministry of the Environment 1970). Only the effluent data for the month of August did not exceed these use criteria indicating that the creek and river water quality is generally unsuitable for agricultural or recreational usage from the standpoint of perceived FS contamination.

Table 3.2

Summary of total coliform, fecal coliform and fecal streptococci geometric mean and maximum concentrations observed at various stations on Wascana Creek, Qu'Appelle River and in effluent during the period July 1 to July 31, 1982

Sampling Station	TC				FC				FS	
	MF		MPN		MF		MPN		MF	
	G.M.	Maximum	G.M.	Maximum	G.M.	Maximum	G.M.	Maximum	G.M.	Maximum
Riske's Crossing	1,184	4,000	826	23,000	128	450	256	2,000	79	180
Regina STP Final Effluent	3,202	93,000	775	93,000	307	43,000	145	43,000	62	520
Sidmar Crossing	7,621	45,000	4,530	23,000	131	650	178	930	128	410
*Above Qu'Appelle	821	2,400	2,522	9,300	57	190	90	90	162	266
*Above Wascana Creek	627	4,300	1,140	4,300	80	950	235	750	173	930
*Highway No. 11	2,110	4,500	6,174	11,000	133	670	926	2,300	298	980
Market Gardens	486	1,600	592	2,300	59	300	55	430	131	340

* less than 5 samples analyzed

Table 3.3

Summary of total coliform, fecal coliform and fecal streptococci geometric mean and maximum concentrations observed at various stations on Wascana Creek, Qu'Appelle River and in effluent during the period August 1 to August 31, 1982

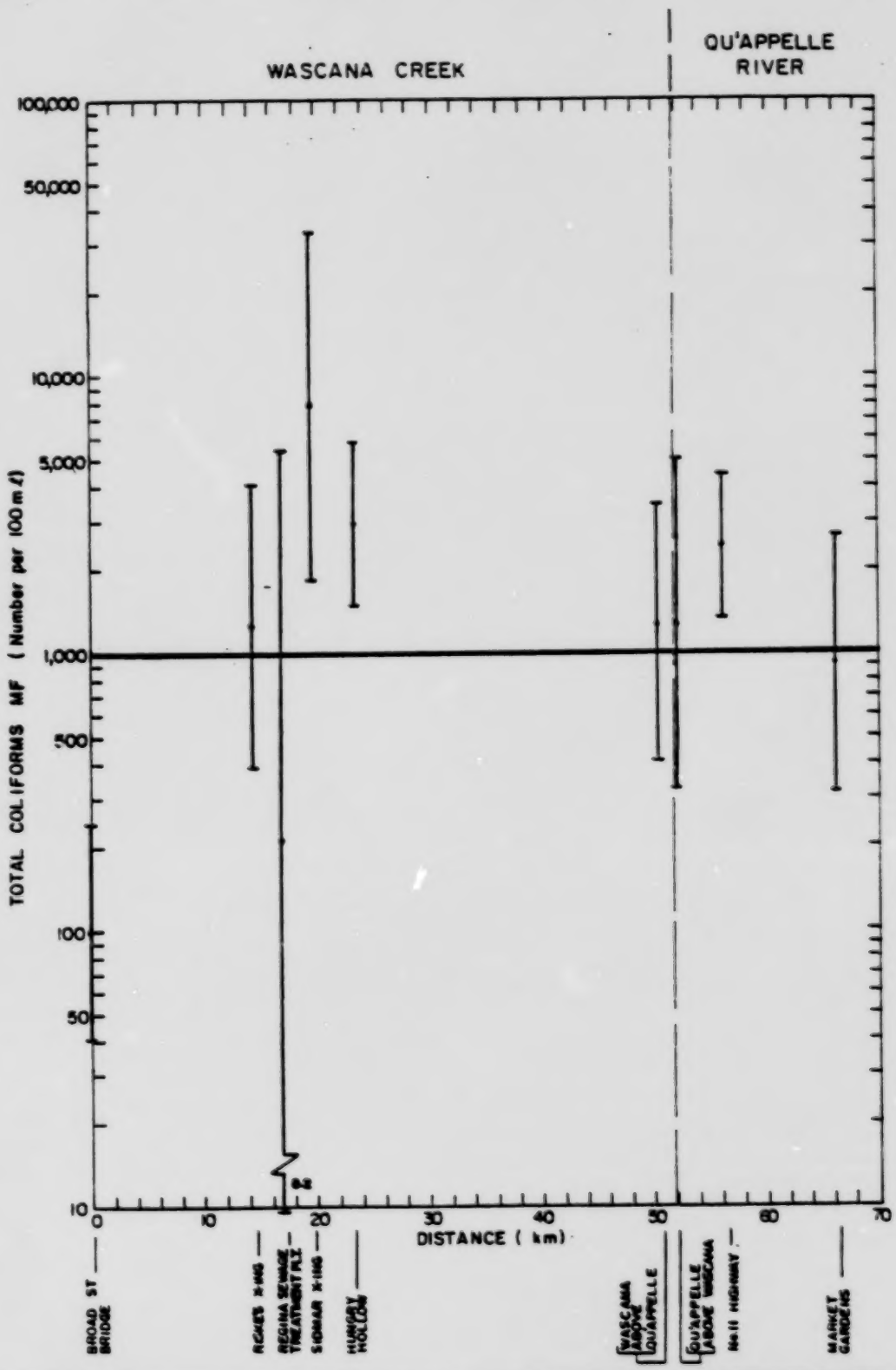
	TC				FC				FS	
	MF		MPN		MF		MPN		MF	
Sampling Station	G.M.	Maximum	G.M.	Maximum	G.M.	Maximum	G.M.	Maximum	G.M.	Maximum
Riske's Crossing	1,301	11,000	480	9,300	20	560	59	4,300	50	840
Regina STP Final Effluent	88	82,000	459	240,000	20	2,000	103	23,000	15	1,000
Sidmar Crossing	7,876	65,000	5,791	460,000	29	1,630	77	1,500	166	800
*Above Qu'Appelle	1,902	3,900	2,168	4,300	50	200	102	430	89	120
Above Wascana Creek	2,214	6,000	372	930	64	220	157	430	82	190
Highway No. 11	2,643	5,000	*273	930	46	120	*148	2,000	78	210
Market Gardens	1,307	11,000	236	2,400	19	110	54	230	51	220

* 4 samples analyzed

With the exception of Sidmar Crossing, the TC and FC geometric mean data for each month suggests that the water quality of the creek and river was suitable for use as a potable water supply if proper treatment were carried out. It was also generally suitable for non-contact recreation. These findings are in agreement with those of Tones (1981).

Additional analyses of the data presented in Appendix 2 was also conducted in order to determine geometric mean values and standard deviation for data concerning each sampling station in the July-August period. These data are presented for the various indicator bacteria and analytical procedures in Figures 3.2.1 to 3.2.5.

Geometric mean values for TC bacteria determined by the MF and MPN procedures are shown in Figures 3.2.1 and 3.2.2, respectively. The horizontal line near the centre of each figure defines the objective level of 1,000 TC per 100 ml. For this 2-month period the level of TC determined by the MF procedure (Figure 3.2.1) exceeded the objective of 1,000 TC per 100 ml at nearly every sampling station, with the exception of the effluent site. The geometric mean for the Market Garden site was only slightly below this objective level. A similar trend is apparent for the MPN data displayed



Saskatchewan Environment Water Pollution Control Branch		GRAPH OF GEOMETRIC MEAN VALUES FOR TOTAL COLIFORM BACTERIA AT VARIOUS SAMPLING STATIONS DURING JULY & AUGUST 1982 (MEMBRANE FILTRATION DATA ± STANDARD DEVIATION)	Figure 3.2.1
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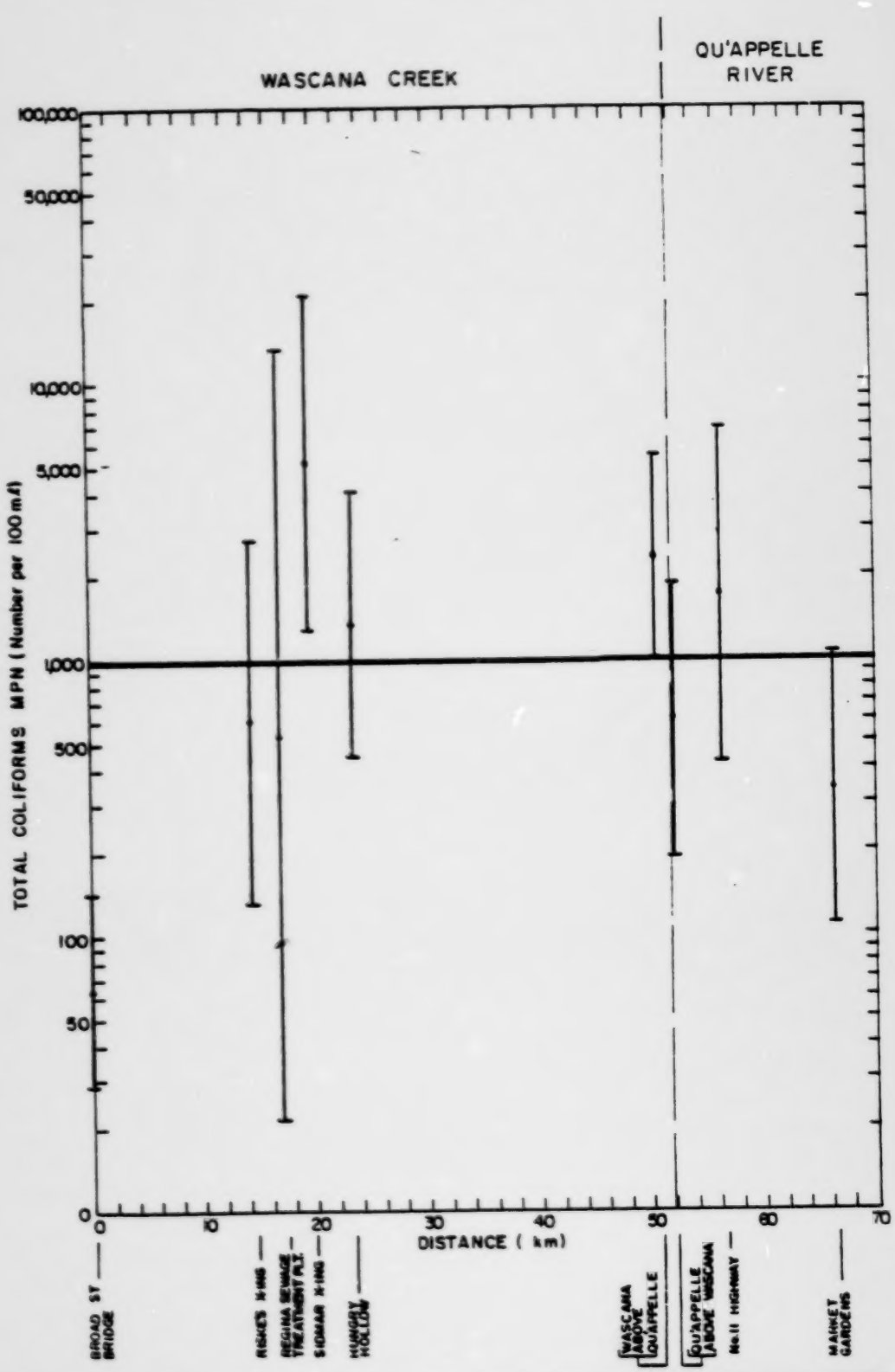

Saskatchewan Environment Water Pollution Control Branch		GRAPH OF GEOMETRIC MEAN VALUES FOR TOTAL COLIFORM BACTERIA AT VARIOUS SAMPLING STATIONS DURING JULY & AUGUST 1982 (MOST- PROBABLE - NUMBER DATA ± STANDARD DEVIATION)	Figure 3.2.2.
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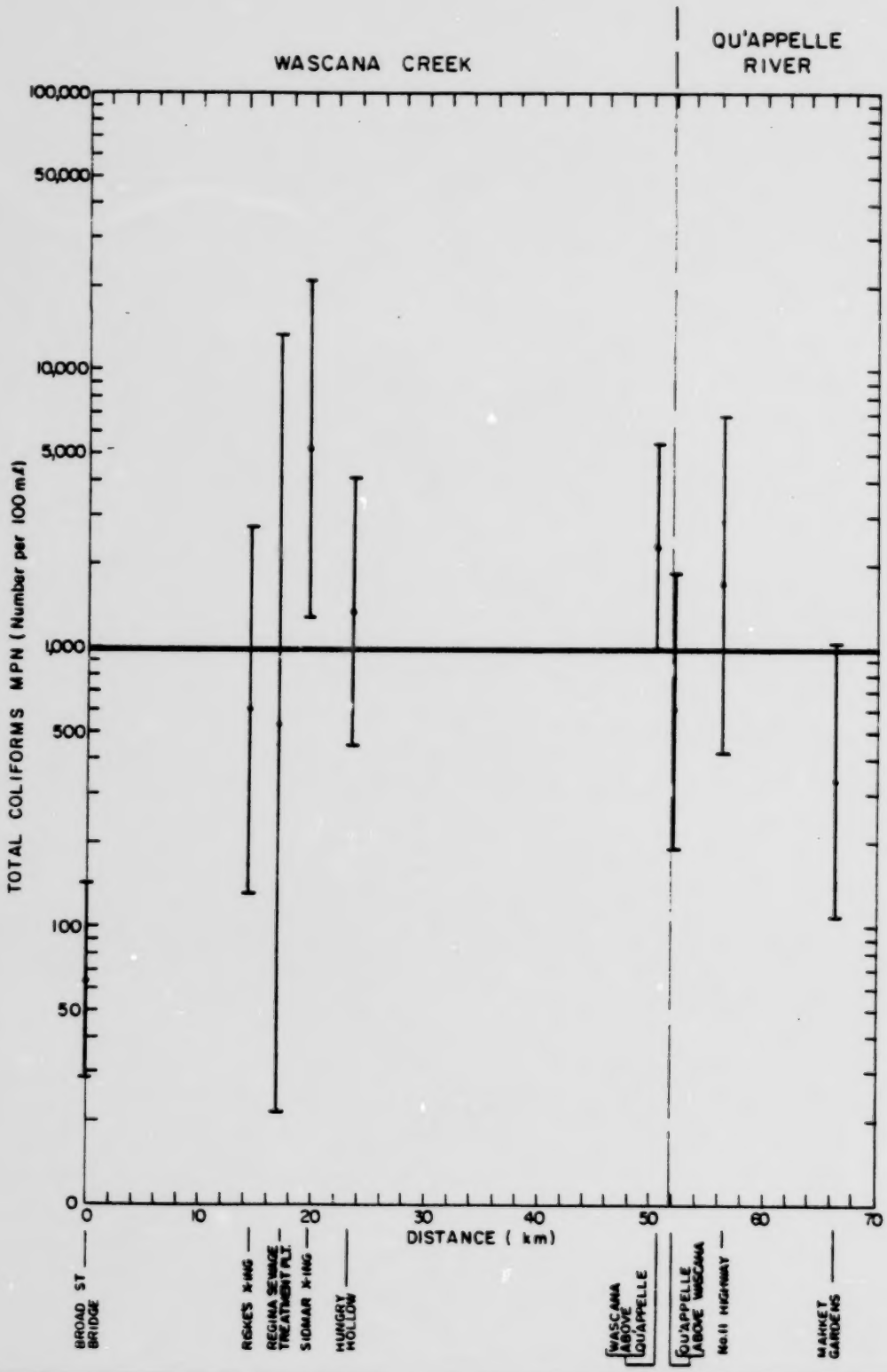

Saskatchewan Environment **Water Pollution Control Branch**	GRAPH OF GEOMETRIC MEAN VALUES FOR TOTAL COLIFORM BACTERIA AT VARIOUS SAMPLING STATIONS DURING JULY & AUGUST 1982 (MOST- PROBABLE - NUMBER DATA ± STANDARD DEVIATION)	Figure 3.2.2.
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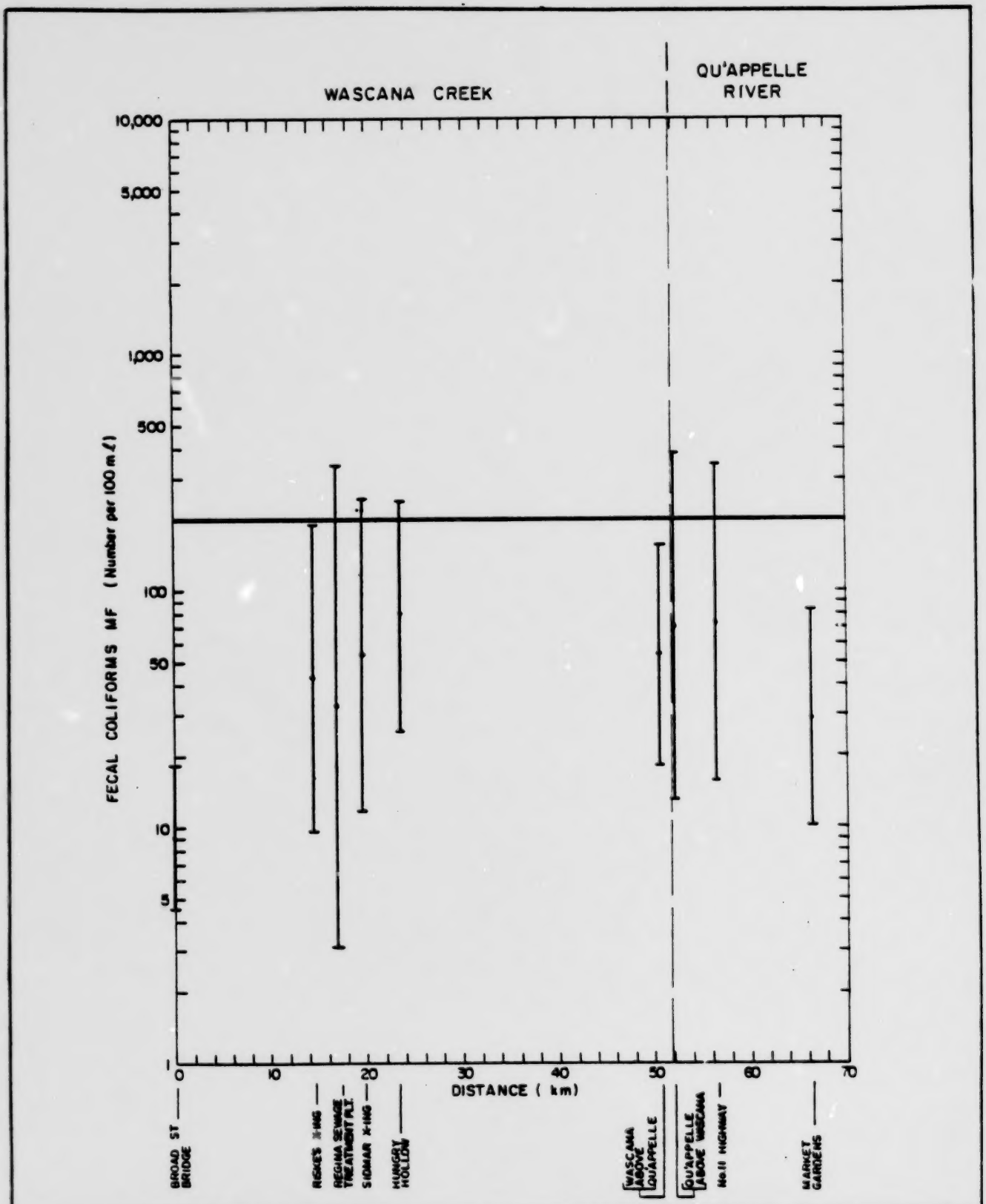
in Figure 3.2.2. In both figures, however, it is apparent that considerable variability in the data existed, particularly for that concerning the treated sewage effluent. Since the sewage effluent is normally disinfected by chlorination, it is not surprising that considerable variability in data for different samples from this station might be observed because the TC bacteria levels are usually near 0 per 100 ml but can infrequently be observed at very high levels (e.g. 240,000 per 100 ml, Appendix 2), possibly resulting from some failure in the sewage treatment regime. At the other sampling stations, however, the apparent variability is not as extreme but is still sufficient to create difficulty in comparing data along the creek or river reaches. In terms of total coliform bacteria, these data do not appear to provide sufficient definition of the indicator bacteria population at each station to permit for the determination of sources of bacteria or for estimating the direct or indirect contribution of the Regina sewage treatment plant effluent to the apparent TC problem in the creek and river. The situation is compounded by the high TC values recorded for Riske's Crossing, a station upstream of the Regina sewage outfall. In the latter portions of this report, some possible explanations for the observed TC results will be presented. What is apparent, however, is that the geometric

mean values for TC bacteria at most sites along the creek and river reaches exceeded the geometric mean objective (1,000 per 100 ml) for direct contact recreation or for vegetable crop irrigation. Also, at Sidmar Crossing, the TC data determined by both analytical procedures exceeded 5,000 TC per 100 ml and were as high as 460,000 TC per 100 ml in August (Table 3.2). This will be addressed again in a later section with regard to the conditions of operation of the Regina Tertiary Treatment Plant.

Figures 3.2.3 and 3.2.4 display the FC geometric mean values, standard deviations and the contact recreation and irrigation objective levels (200 FC per 100 ml) for stations along the creek and river in July and August, 1982. The results for MF analyses include only geometric mean values that are below the objective level. There was a tendency for higher geometric mean values for FC determined by the MPN procedure (Figure 3.2.4) and the recreation/irrigation objective level was exceeded at one station (Highway 11) based on MPN data. Again, however, the standard deviations were sufficient to prevent discernible differences between stations from being observed. In fact, there was relatively little difference between FC geometric mean values from Riske's Crossing to the Market Garden area apparent among either MF or MPN data. On



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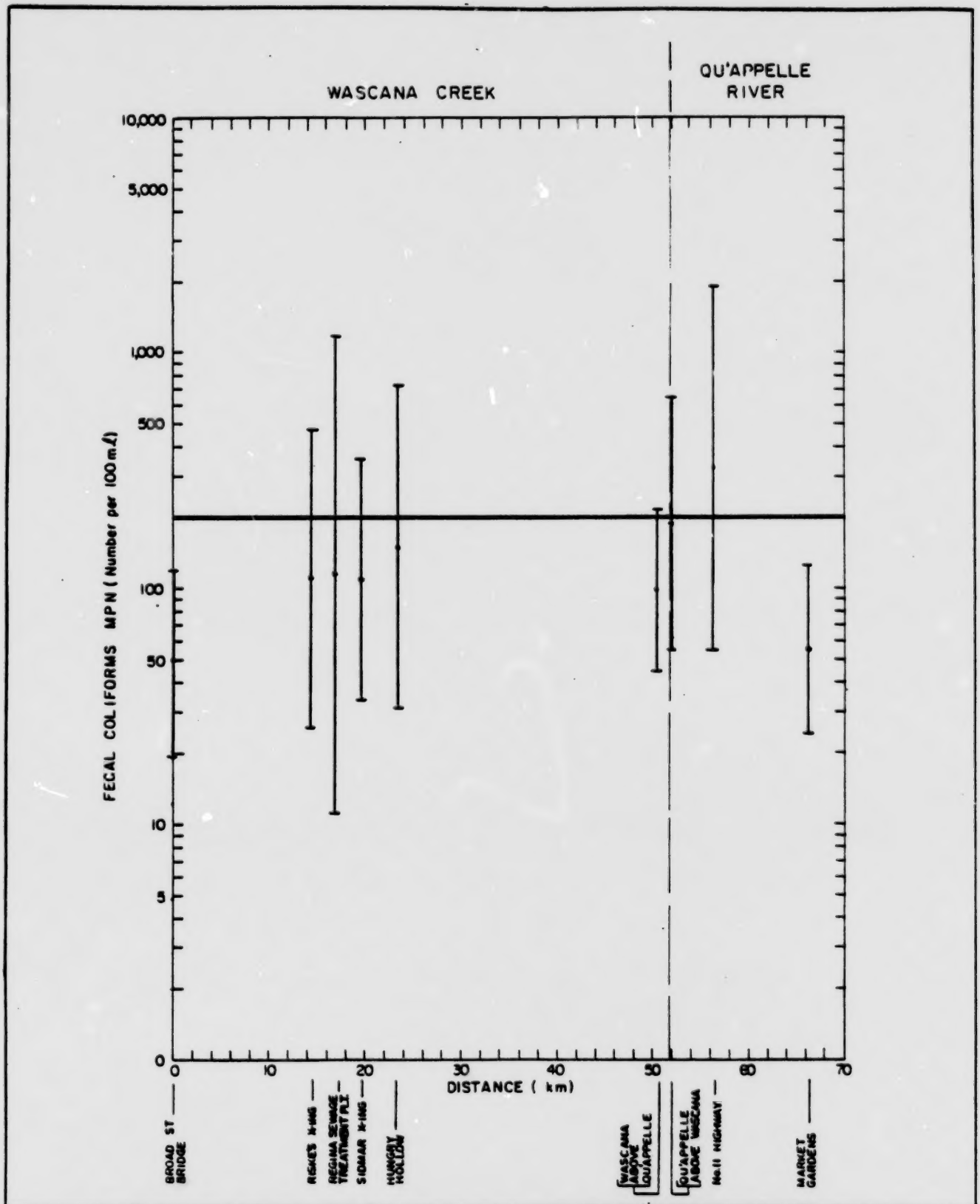
GRAPH OF GEOMETRIC MEAN VALUES FOR FECAL COLIFORM BACTERIA AT VARIOUS SAMPLING STATIONS DURING JULY & AUGUST 1982
(MEMBRANE FILTRATION DATA± STANDARD DEVIATION)

Figure 3.2.3



Saskatchewan Environment **Water Pollution Control Branch**		GRAPH OF GEOMETRIC MEAN VALUES FOR FECAL COLIFORM BACTERIA AT VARIOUS SAMPLING STATIONS DURING JULY & AUGUST 1982 (MOST PROBABLE - NUMBER DATA ± STANDARD DEVIATION)	Figure 3.2.4
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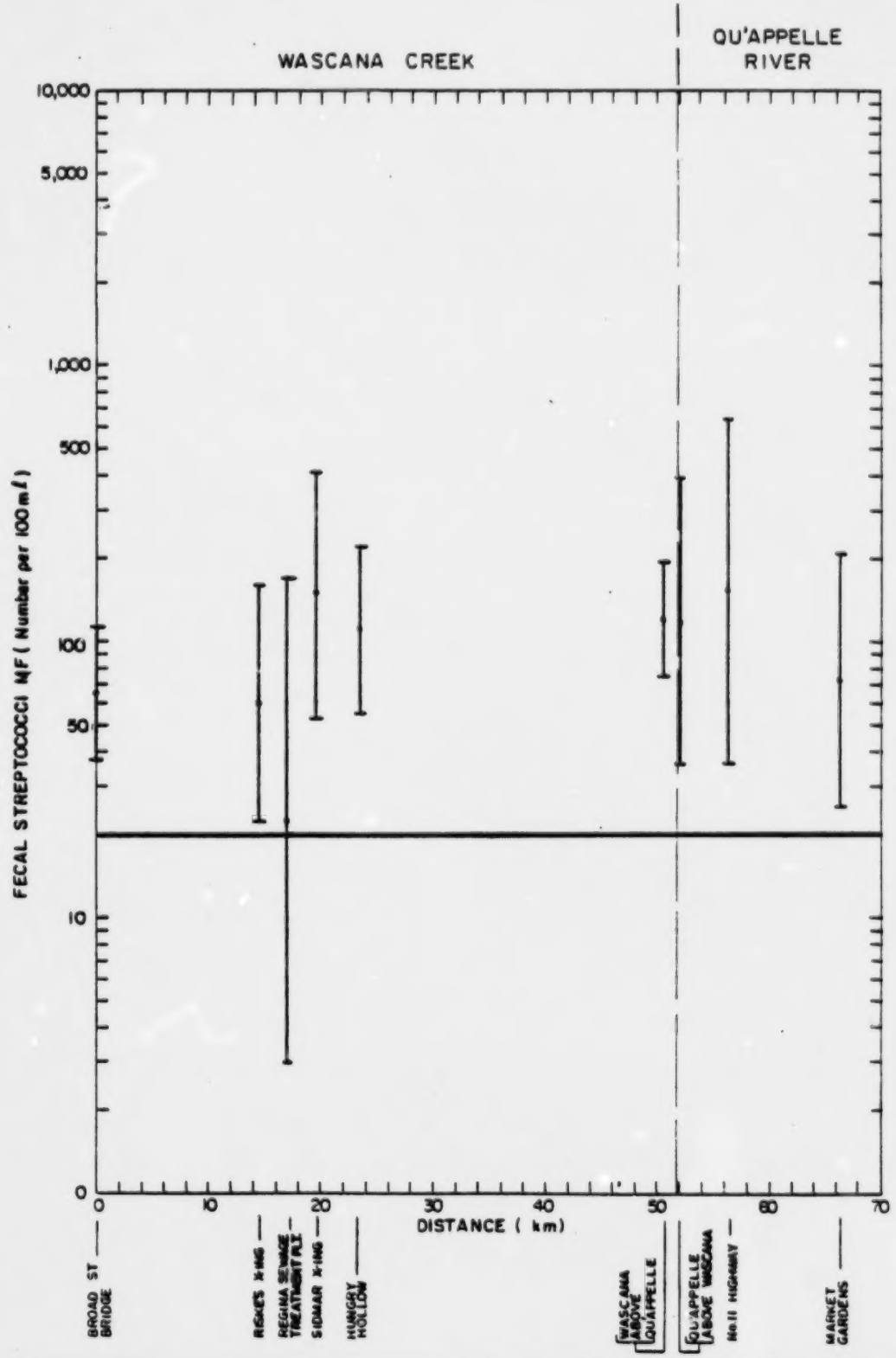
the basis of these results, the geometric mean objective level for FC was only exceeded at the Highway 11 station (MPN data only). Therefore, the water at all other stations could be viewed as acceptable for vegetable crop irrigation, for contact recreation, as well as for non-contact recreation and for treatment and distribution as a potable supply. However, as will be apparent in the following discussion, other methods of determining exceedences of objective levels for FC could be used to arrive at totally opposite conclusions with respect to the suitability of the creek and river for irrigation and recreational use.

Before proceeding to these other considerations regarding coliform bacteria, it is useful to consider the levels of fecal streptococci (FS) or enterococci in the water bodies. Although Saskatchewan does not currently have surface water quality objectives for FS, these bacteria are frequently utilized in conjunction with FC in the assessment of surface water quality. At least one province has water quality guidelines and criteria relating FC/FS ratio to origin of pollution or concerning maximum permissible levels of streptococci in water intended for various uses. There is general acceptance of the concept that good management of livestock should exclude their being watered with runoff from livestock operations or with water contaminated by effluents

of human or animal origin. In Ontario, the quality of recreational waters had been considered impaired if enterococcus levels exceed 20 FS per 100 ml. The same criterion was suggested for vegetable crop irrigation while a level of 40 FS per 100 ml was cited as the permissible level for livestock watering (Ontario Ministry of the Environment 1970). Currently, FS guidelines in Ontario are no longer in effect, however, because of evidence that some detectable waterborne species of FS may be of uncertain (e.g. nonfecal) origin (Ontario Ministry of the Environment 1979). However, for FS detected in municipal effluent, there is a high probability of them being of human intestinal origin.

The geometric mean values and standard deviations for FS at various stations along the creek and river during July and August, 1982 are displayed in Figure 3.2.5. Since the analytical laboratory does not possess the capability to perform analyses for FS by MPN, only data derived using the MF procedure is available. The methodology employed is considered to be relatively reliable in detecting and enumerating streptococci of intestinal origin (Pagel and Hardy 1979, unpublished report).

It is clearly evident from Figure 3.2.5 that the geometric mean values for FS exceed the 1970 Ontario criteria (20 FS per



Saskatchewan Environment

Water Pollution Control Branch

Drn G V J	Date JUNE 1983
Ck'd	Plan No. F 7-5-1-3(18)

GRAPH OF GEOMETRIC MEAN VALUES FOR FECAL STREPTOCOCCI BACTERIA AT VARIOUS SAMPLING STATIONS DURING JULY & AUGUST 1982

(MEMBRANE FILTRATION DATA ± STANDARD DEVIATION)

Figure 3.2.5

100 ml) for irrigation and contact recreation at all stations along the creek and river. In fact all stations, except for the effluent outfall, were also characterized by FS levels which exceeded the former Ontario criterion for livestock watering (40 FS per 100 ml). Similarly, the 1970 Ontario permissible criterion for use of the water for a public surface water supply of 50 FS per 100 ml was also exceeded at all stations except the effluent outfall. As mentioned earlier with regard to TC, the relatively lower geometric mean values for indicator bacteria in the Regina sewage effluent may be attributable to chlorination practices which normally would reduce the indicator bacteria levels to near zero. FS levels for single samples in the effluent, however, were as high as 1,000 FS per 100 ml (Table 3.2). Because of their possible human enteric origin, such occurrences of elevated FS levels in the effluent may be of health and water quality concern.

The foregoing sections have discussed the results of indicator bacteria analyses utilizing geometric mean values for data collected during the primary irrigation period of 1982. On the basis of these data, water quality at most sites along the creek were found to be unfit for contact recreation or for vegetable crop irrigation due to elevated TC geometric mean levels. Geometric mean FS but not FC levels support this

water quality evaluation as well, although no criteria or objectives for FS have been established for Saskatchewan.

In addition to the use of calculated geometric mean values for TC and FC, other objectives for indicator bacteria also may be used to assess the quality of water intended for various uses. The alternative objectives include various frequencies of exceedances of specific levels of TC and/or FC in samples collected over not more than a 1-month interval (30 days). For instance, in the case of use of surface water for treatment and distribution as a potable supply or for non-contact recreation, at least 90 per cent of samples should have less than 5,000 TC per 100 ml and less than 1,000 FC per 100 ml. Both variables would necessarily have to be at relatively elevated levels to indicate an unsuitable water quality for these uses. As indicated by Tones (1981) and in the attached data (Appendix 2), this dual-variable objective is seldom exceeded. However, as noted in the provincial surface water quality objectives (Saskatchewan Environment 1977), Saskatchewan Environment may establish maximum permissible limits for TC in a single sample at specific locations.

With respect to vegetable crop irrigation and contact recreation, the geometric mean values established for TC

(1,000 TC per 100 ml) and FC (200 FC per 100 ml) for at least 5 samples collected over a 30-day period are not to be exceeded in more than 20 per cent of the samples collected during any month, nor is there to be more than 2,400 TC per 100 ml detected on any day. In Tables 3.4.1 - 3.4.4 the data in Appendix 2 concerning TC and FC levels in the creek and river have been presented to indicate their relationship to the above objectives. It is clearly evident that in both July and August the incidence of samples containing more than 2,400 TC per 100 ml was significant for each waterbody since, by both analytical procedures, elevated TC levels were encountered at all stations, except at the Market Gardens in July (Tables 3.4.1, 3.4.2). In July, however, maximum values for TC of 1,600 and 2,300 TC per 100 ml were recorded for the Market Gardens station following sample analyses by the MF and MPN procedures, respectively (Table 3.2). Therefore, TC levels at most stations on the creek and river in individual samples indicate that the objective concerning the maximum permissible TC level on any day was frequently exceeded.

In July, the objective level of 1,000 TC per 100 ml was exceeded in 64.5 per cent of the 62 samples from the creek. The frequency of exceedance was 22.2 per cent at the Market Gardens (both MF and MPN data) while at Sidmar Crossing 93 per cent of the 15 samples analysed had levels of TC above 1,000

Table 3.4.1

Summary of total coliform (TC) results for samples collected along Wascana Creek and Qu'Appelle River in July, 1982

Sampling Station	Number of Samples Analyzed		Number of Samples with TC Level Exceeding 2,400/100 ml		Percentage of Samples with TC Level Exceeding 2,400/100 ml		Percentage of Samples with TC Level Exceeding 1,000/100 ml	
	MF	MPN	MF	MPN	MF	MPN	MF	MPN
Wascana Creek								
Riske's Crossing	15	13	4	4	26.7	30.8	53.3	53.9
Regina STP	7	10	4	3	57.1	30.0	85.7	50.0
Sidmar Crossing	15	15	14	12	93.3	80.0	93.3	93.3
Hungry Hollow	3	4	2	2	66.7	50.0	100.0	75.0
Old Crossing	--	1	--	1	--	100.0	--	100.0
Battered Bridge	1	1	0	0	0	0	0	100.0
Above Qu'Appelle River	4	3	1	1	25.0	33.3	50.0	66.7
Qu'Appelle River								
Above Wascana Creek	4	3	1	1	25.0	33.3	50.0	66.7
No. 11 Highway	4	3	2	2	50.0	67.7	75.0	100.0
Market Gardens	9	9	0	0	0	0	22.2	22.2
TOTALS	62	62	28	26	45.2	41.9	64.5	64.5

MF - membrane filtration
MPN - most-probable-number

Table 3.4.2

Summary of total coliform (TC) results for samples collected along Wascana Creek and Qu'Appelle River in August, 1982

Sampling Station	Number of Samples Analyzed		Number of Samples with TC Level Exceeding 2,400/100 ml		Percentage of Samples with TC Level Exceeding 2,400/100 ml		Percentage of Samples with TC Level Exceeding 1,000/100 ml	
	MF	MPN	MF	MPN	MF	MPN	MF	MPN
Wascana Creek								
Riske's Crossing	21	21	9	3	42.9	14.3	61.9	19.1
Regina STP	19	21	4	8	21.1	38.1	26.3	38.1
Sidmar Crossing	17	20	15	14	88.2	70.0	88.2	80.0
Hungry Hollow	3	4	1	0	33.3	0	100.0	0
Old Crossing	--	--	--	--	--	--	--	--
Battered Bridge	--	--	--	--	--	--	--	--
Above Qu'Appelle River	4	4	2	2	50.0	50.0	75.0	75.0
Qu'Appelle River								
Above Wascana Creek	5	4	2	0	40.0	0	80.0	0
No. 11 Highway	5	3	2	0	40.0	0	100.0	0
Market Gardens	15	14	3	1	20.0	7.1	60.0	14.3
TOTALS	89	91	38	28	42.7	30.8	64.0	36.3

MF - membrane filtration
MPN - most-probable-number

per 100 ml (Table 3.4.1). A similar situation was observed for the creek and river stations in August with the frequency of exceedance ranging from 26.3 per cent at the effluent outfall to 100 per cent at Hungry Hollow for MF data. For MPN data, only Riske's Crossing and Market Gardens did not exceed the 1,000 TC per 100 ml objective in more than 20 per cent of of the samples. These data again indicate the total coliform bacteriological quality of the creek and river reaches examined to have been generally unsuitable for contact recreation or for vegetable crop irrigation during July and August, 1982, in terms of existing surface water quality objectives.

Fecal coliform results for July and August, when considered in terms of the frequency at which the objective level of 200 FC per 100 ml was exceeded, also indicate the creek and river water to have been unsuitable for contact recreation or for vegetable crop irrigation during July and August, 1982. These data are presented in Tables 3.4.3 and 3.4.4 with regard to July and August, respectively.

In July, only the MPN data for FC at Market Gardens did not exceed the FC objective level of 200 FC per 100 ml in more than 20 per cent of the samples. During July, the frequency of exceedance for the creek and river stations ranged from

Table 3.4.3

Summary of fecal coliform (FC) results for samples collected along Wascana Creek and Qu'Appelle River in July, 1982.

Sampling Station	Number of Samples Analyzed		Number of Samples with FC Levels Exceeding 200/100 ml		Percentage of Samples with FC Levels Exceeding 200/100 ml	
	MF	MPN	MF	MPN	MF	MPN
Wascana Creek						
Riske's Crossing	15	13	6	6	40.0	46.2
Regina STP	7	10	3	4	42.9	40.0
Sidmar Crossing	15	15	7	8	46.7	53.3
Hungry Hollow	3	4	2	3	66.7	75.0
Old Crossing	--	1	--	1	--	100.0
Battered Bridge	1	1	0	0	0	0
Above Qu'Appelle River	4	2	0	0	0	0
Qu'Appelle River						
Above Wascana Creek	4	3	2	2	50.0	66.7
No. 11 Highway	4	3	2	3	50.0	100
Market Gardens	9	8	2	1	22.2	12.5
TOTALS	62	60	24	28	38.7	46.7

MF - membrane filtration

MPN - most-probable-number

Table 3.4.4

Summary of fecal coliform (FC) results for samples collected along Wascana Creek and Qu'Appelle River in August, 1982.

Sampling Station	Number of Samples Analyzed		Number of Samples with FC Levels Exceeding 200/100 ml		Percentage of Samples with FC Levels Exceeding 200/100 ml	
	MF	MPN	MF	MPN	MF	MPN
Wascana Creek						
Riske's Crossing	22	21	2	3	9.1	14.3
Regina STP	22	21	5	5	22.7	23.8
Sidmar Crossing	22	21	1	5	4.6	23.8
Hungry Hollow	4	4	0	0	0	0
Old Crossing	--	--	--	--	--	--
Battered Bridge	--	--	--	--	--	--
Above Qu'Appelle River	4	4	1	1	25	25
Qu'Appelle River						
Above Wascana Creek	5	4	2	2	40	50
No. 11 Highway	5	3	0	0	0	0
Market Gardens	15	14	0	2	0	14.3
TOTALS	99	92	11	18	11.1	19.6

MF - membrane filtration

MPN - most-probable-number

22.2 to 66.7 per cent. In August, the FC objective level was less frequently exceeded with a tendency for MPN data to exceed the objective level more frequently than did MF data.

The FC data for July (Table 3.4.3) examined in terms of frequency of exceedance indicates that the creek and river in July were of questionable water quality with respect to use for contact recreation or for vegetable crop irrigation. This is contrary to the conclusions regarding the suitability of the water for these uses based upon geometric mean values (Tables 3.2, 3.3) for FC in July and August, 1982. In August, the objective related to frequency of levels of FC above 200 FC per 100 ml was exceeded only at the effluent outfall, at Sidmar Crossing (MPN data only), on Wascana Creek above the Qu'Appelle River, and on the Qu'Appelle River above Wascana Creek (Table 3.4.4).

There is another objective pertaining to the operating conditions of the Regina tertiary treatment plant, and not to surface waters in general, which should be noted in this report, since Wascana Creek is the receiving water body for this sewage treatment plant. Currently, the conditions of approval for the treatment plant to operate specifies the following with regard to effluent disinfection or for TC and FC levels in the creek at Sidmar Crossing:

> "Unless otherwise approved, the sewage effluent shall be disinfected during the period May 15 to September 20 in such a manner to achieve a total chlorine residual of 0.5 mg/l after 15 minutes contact time or alternatively to ensure that the water in Wascana Creek near SW 11-18-21-W2 does not contain more than 5,000 total coliforms per 100 ml nor 1,000 fecal coliforms per 100 ml during this period."

The Certificate of Approval to Operate for the tertiary treatment plant is attached as Appendix 3.

The FC level of 1,000 FC per 100 ml was very rarely exceeded at Sidmar Crossing. However, at this station the TC level specified in the conditions of approval to operate (5,000 TC per 100 ml) was exceeded in 80 per cent of the 15 July samples and in 70.6 per cent of the 17 August samples analysed by MF. The corresponding MPN results for July and August revealed exceedances of 33.3 and 45.0 per cent, respectively.

A summary of these results are shown in Table 3.4.5. These results clearly indicate that the conditions of operation of the Regina tertiary treatment plant (Appendix 3) are frequently not achieved with respect to observed TC bacteria levels at Sidmar Crossing. This is not an unusual or unexpected observation, however, since TC at similarly elevated levels were also intermittently observed in the sewage effluent (Appendix 2). Levels of TC above 5,000 per 100 ml were only rarely observed in July and August at Riske's

Crossing, however. Because of the potential for interferences with the results of TC analyses, particularly in nutrient-enriched waters with high algae populations, the significance of the TC must be tempered since no confirmatory testing or species identifications of the observed TC were conducted.

Table 3.4.5

Summary of total coliform (TC) results for samples collected from Sidmar Crossing on Wascana Creek in July and August, 1982

	Number of Samples Analyzed		Number of Samples with TC Levels Exceeding 5,000/100 ml		Percentage of Samples with TC Levels Exceeding 5,000/100 ml	
Month	MF	MPN	MF	MPN	MF	MPN
July	15	15	12	5	80.0	33.3
August	17	20	12	9	70.6	45.0
TOTALS	32	35	24	14	75.0	40.0

MF - membrane filtration
MPN - most-probable-number

3.3 Indicator Bacteria Concepts

Coliform bacteria are an arbitrarily defined group of bacteria which produce specific biochemical reactions in defined artificial growth media. Generally, the coliforms are perceived as bacterial groups which are comprised of "enteric" species

(members of the family Enterobacteriaceae) or, as the name "coliform" suggests, are derived from the intestinal tract or colon of animals. However, in reality, the procedures employed to isolate and enumerate "coliform" bacteria provide estimates of numbers of bacteria with arbitrary chemical or morphological characteristics and not necessarily estimates of true enteric species populations. Nevertheless, the coliform indicator groups, TC and FC, have been extensively used to assess water quality for various use purposes, to test the safety of drinking water and, in conjunction with measurements of FS, have been used to determine the origin of perceived fecal pollution which the coliform groups are assumed to indicate.

The basic premise upon which the indicator bacteria concepts is based is one that assumes a relationship between numbers of pathogenic bacteria or other microbes of fecal origin and coliform or streptococci (enterococci) indicator groups of bacteria of the same fecal origin. The indicator groups are generally present in feces or raw sewage at much greater densities than are the pathogens. Therefore, the assumption is made that when indicator bacteria are present in water at specific concentrations or at other concentrations observed at specific frequencies, the presence of pathogenic bacteria is also likely. While this assumption may be reasonably valid

when examining waters contaminated very recently with raw sewage, the related concepts are not necessarily valid due to differential rates of dying, survival, and even reproduction of various indicator and pathogenic species following their discharge into a receiving water body. The assumed relationship between indicator bacteria and pathogens becomes less valid with the passage of time and distance from the point of entry of the feces into water. Further difficulties in determining the bacteriological quality are encountered due to the influence of contributions of indicator bacteria and pathogens to water from non-human animals in whose feces the relationship between indicator bacteria and pathogens is different or unknown. Also, many naturally occurring bacterial genera (e.g. Aeromonas, Enterobacter, Klebsiella) may be present in water or be contributed to water through the erosion of plant debris and soil. These species, although not of intestinal or fecal origin, may contribute significantly to the observed indicator (TC, FC) levels in water. The current enumeration procedures for TC are particularly subject to interferences due to bacteria of non-fecal origin which mimic "coliforms" or which mask the presence of bacteria that may be of water quality significance (Dutka 1973; Ptak, Ginsburg and Willey 1974; Bonde 1977; Grabow and Preez 1979).

In assessing the bacteriological quality of surface waters, therefore, it is necessary to consider the limitations which are inherent in the current analytical procedures for determining TC, FC and FS levels. High values of indicator bacteria, whether they are of fecal origin or not, signify unusual conditions in a water body. They indicate a potential for the presence of Salmonella or other pathogens. In many instances, however, pathogens may be present in water which contains relatively few indicator bacteria (Smith, Twedt and Flanigan 1973). Therefore, the absence or detection of low levels of indicator bacteria is not assurance of the absence of pathogens. Under these latter conditions the observations made during sanitary surveys of a waterbody might be assigned greater importance in the evaluation of potential risks associated with intended water uses such as for crop irrigation or livestock watering. This aspect is considered in greater detail in Section 3.3.2.

The subject of current indicator bacterial concepts is in need of highly technical and critical review. It is not the purpose of this report to extensively review the literature on the subject but rather to draw attention to some of the limitations of current procedures for estimating indicator bacteria levels in water. In the following section (3.4) some of these limitations will be described as they may relate to the creek and river under discussion.

3.3.1 Sources of Indicator Bacteria in Wascana Creek and Qu'Appelle River

One of the most frequently employed methods of determining the origin of perceived fecal pollution in water is that of the FC/FS ratio. The use of this ratio to describe the origin of fecal pollution stems mainly from the research of Geldreich and his colleagues (e.g. Geldreich, Clark and Huff 1964; Geldreich and Kenner 1969) who consistently observed a relationship between concentrations of FC and FS in wastewaters and receiving waters near the outfall areas. Despite the cautionary statements made by these researchers with respect to the application of the FC/FS ratio to water quality interpretation the ratio has been extensively misapplied to situations where the relationship between FC and FS cannot be considered to accurately reflect the origin of the perceived bacterial pollution.

The hypothesis of Geldreich et al (1963) was based upon relationships between numbers of FC and FS observed in the feces of humans and other animals. They also observed similar relationships between these bacterial groups in waste stabilization ponds. They found, for instance, that FC levels in human

feces always exceeded those of FS by a factor greater than 4.0 and observed a similar relationship in domestic wastewater. By examining the feces of various fowl and livestock they found that the FC/FS ratio was consistently at or below 0.6 in feces from these non-human sources. Wastewaters or water bodies contaminated by a variety of wastes would therefore be characterized by FC/FS ratios between approximately 0.7 and 4.0. Geldreich and Kenner (1969) warned, however, that the ratios must be applied carefully since they are most meaningful at waste outfalls and become less relevant with the passage of time and distance from the original point of entry of the feces into water. Geldreich (1976), in an extensive review of the FC/FS ratio, reaffirmed the warning by providing evidence that cattle manure initially has an average FC/FS ratio of usually 0.2. However, after prolonged stream residence, the ratio from this source may increase to as high as 3.0 due to a differentially higher rate of die off of several enterococcal species. It is therefore unlikely that the ratios would apply to wastewaters which receive much more extensive treatment (flocculation, filtration, long-term retention, chlorination) than did the original oxidation ponds studied by Geldreich

and his colleagues. Some of the factors contributing to the reduction in significance of the FC/FS ratio with the passage of time and distance relate to differential survival rates and/or growth rates of these indicator bacteria in water (Hendricks 1972; Doran and Linn 1979; Yeager and Ward 1981), to physiological changes in the bacteria possibly related to the water environment which alters their detectability by current analytical procedures (Kasweck and Fliermans 1978; Rychert and Stephenson 1981), to differential responses to disinfection treatment (Camper and McFeters 1979), to the presence of naturally occurring bacterial species which may mimic indicator bacteria or add to the observed indicator populations (Geldreich 1983), and to diffuse inputs of indicator bacteria which are not necessarily of fecal origin (Doran and Linn 1979) but which alter the FC/FS ratio. Resuspension of sediments may also have pronounced influences both on the perceived FC/FS ratio of the water and on the bacteriological quality of the waterbody (McDonald, Kay and Jenkins 1982).

In the case of Wascana Creek and the Qu'Appelle River, it is known that tertiary treated effluent

from the City of Regina at least intermittently is contributed indicator bacteria to the creek during the months of July and August, 1982. During the remainder of the year in which chlorination of this effluent is not practiced, substantial contributions of indicator bacteria to the creek obviously occur. This may, as might intermittent pollution events (e.g. stormwater inflows, chlorination failures, sewage bypasses) in summer, exert an influence on water quality at later times when sediments become resuspended during increased runoff events (McDonald et al 1982) especially if spring runoff flows do not scour the benthic sedimentary deposits. What is apparent from the data obtained for the effluent during July and August of 1982 is that the FC/FS ratio (1.43, Table 3.5.1) does not indicate clearly a human source of fecal contamination even though the effluent is largely domestic sewage. The FC/FS ratio at this site, however, was the greatest ratio observed for all sites during the study period. Factors described above probably best account for the relatively low FC/FS ratio regarding the effluent.

The FC/FS ratios for each station are presented in Table 3.5.1. These data indicate, in most instances,

Table 3.5.1

Ratios of geometric mean values of fecal coliform (FC) to fecal streptococci (FS) determined by membrane filtration of samples collected along Wascana Creek and Qu'Appelle River in July and August, 1982

Sampling Station	MF (no./100 ml)		
	FC	FS	FC/FS
Wascana Creek			
Riske's Crossing	42.6	60.5	0.70
Regina STP	32.1	22.5	1.43
Sidmar Crossing	53.8	149.3	0.36
Hungry Hollow	78.0	110.8	0.70
Old Crossing	--	--	--
Battered Bridge	--	--	--
Above Qu'Appelle River	53.5	120.3	0.44
Qu'Appelle River			
Above Wascana Creek	70.4	119.0	0.59
No. 11 Highway	73.3	152.8	0.48
Market Gardens	28.7	72.4	0.40

a predominantly domestic animal or livestock and/or wildlife source of indicator bacteria. The sources of contamination to Wascana Creek may include diffuse inputs from wildlife (waterfowl, furbearers, rodents, etc.), livestock (Appendix 1), rainfall runoff events, as well as effluent discharges of intermittent poor quality and unidentified storm

water and/or sanitary sewer discharges of unpredictable nature. The available bacteriological data (Appendix 2; Tones 1981) do not readily help to identify the bacterial sources although their impacts on water quality are significant in terms of current water use objectives. The situation is further obscured by the relatively poor indicator bacteriological water quality observed upstream of the effluent discharge point at Riske's Crossing (Appendix 2) and by technical limitations in the analytical procedures which cast doubt on the reliability and/or significance of the total coliform data in particular (e.g. Dutka 1973).

The data for TC, FC and FS for the creek and river (e.g. Figures 3.2.1-3.2.5) do not show any apparent trend towards declines in numbers of bacteria from the area of the most apparent source of indicator bacteria, the effluent outfall, to the market garden area. In fact, at the effluent outfall the geometric mean values for TC, FC and FS in most instances tends to be lower, albeit generally with greater variability, than at other sites. The question of bacterial regrowth, analytical methods lacking selectivity or specificity and diffuse and possible

uncontrollable inputs of bacteria along the entire creek and river reach under study cannot be disregarded as possible explanations for these observations. These factors may make the accurate determination of various sources of bacteria and of the relative impacts of municipal storm waters and sewage effluents upon the creek and river very difficult or impossible to achieve.

Tones (1981) calculated geometric mean values for historical data (1969 to 1980) concerning TC and FC bacteria in the creek and river. Plots of these values showed a significant reduction of TC and FC following the advent of tertiary treatment at the Regina sewage treatment plant in 1976. It also indicated, for both pre and post tertiary treatment periods, trends towards lower indicator bacteria levels with increasing distance below the effluent outfall. Also, the highest geometric mean values were determined for the effluent and Sidmar Crossing samples. The reduction in indicator bacteria levels was accounted for by bacterial die-off. These observations, however, were not characteristic of the data obtained in July and August of 1982.

Tones (1981) also calculated FC/FS ratios for the 11 year period 1969-1980 and reported ratios of 0.25 to 0.65 for stations above and below Wascana Lake, respectively, and a ratio of 2.5 at both the Riske's Crossing and above Qu'Appelle River stations. For the above Wascana Creek and Highway 11 stations on the Qu'Appelle River, ratios of 1.3 and 2.2 were reported, respectively. She concluded that the increased FC/FS ratio at Riske's Crossing may indicate a source of contamination upstream of the effluent outfall. The low values for FC/FS ratios for the Qu'Appelle River stations were suggested to be consistent with the fact that the locations were some distance from the source. The "source", however, was never identified.

As in the July/August 1982 survey, no FC/FS ratios reported by Tones (1981) were clearly indicative of recent pollution by human feces. The following potential sources of indicator bacteria are therefore presented to help explain the observed indicator levels:

3.3.1.1 Sewage Bypasses

Sewage plant bypasses occurring at the McCarthy

Street pumping station may intermittently introduce raw, but partially disinfected, sewage or sewage and stormwater. Such occurrences, generally related to heavy rainfall events may intermittently cause high indicator levels to be detected at Riske's Crossing if monitoring occurs shortly after the bypass event, and/or is possibly influenced by resuspended fecal matter or bacteria deposited below the bypass outfall.

3.3.1.2 Stormwater and Runoff

Stormwater runoff related to heavy rainfall events may contribute substantial amounts of fecal matter (of mostly animal origin) and indicator bacteria of fecal and non-fecal origin to the creek via the storm sewer outfalls and flood control channels of Regina. In July and August of 1982, significant rainfall in the Regina area occurred only in July. The rainfall measurements for this period are recorded in Table 3.5.2. Although bacteriological monitoring was not specifically conducted to determine the influence of rainfall events, the data in Appendix 2 for TC, FC and FS show no apparent relationship at any station on the creek or river to the highest rainfall values observed between July 16 and 22, 1982. Tones (1981)

Table 3.5.2

Summary of rainfall measurements for the City of Regina in July and August, 1982*

July		August	
Date	Amount (mm)	Date	Amount (mm)
1	0.2	2	0.8
2	16.2	3	0.6
5	TRACE	5	1.2
6	4.6	11	1.4
8	1.4	12	0.9
11	TRACE	17	3.8
14	3.6	18	6.0
15	3.2	21	4.4
16	29.8	22	5.2
17	17.7	23	TRACE
18	TRACE	24	0.2
22	28.4	26	TRACE
26	TRACE	27	TRACE
		28	TRACE
		29	0.2
		30	TRACE

* for dates not shown no precipitation was detected.
- data supplied by Environment Canada.

reported that flow in Wascana Creek was not a major factor influencing coliform densities, however, so the influence of runoff on the creek and river bacteriological quality remain to be determined.

Further studies should attempt to confirm the likely contributions of indicator bacteria and pathogens (e.g. salmonellae) from the storm sewers to the creek but quantitative determinations of their impact on the creek water quality would be very difficult to achieve.

3.3.1.3 Sewage Bypasses at Treatment Plants

Sewage bypasses at the primary and tertiary plants may occur due to system overload, mechanical failures and due to maintenance or construction activities. Generally, these bypasses are chlorinated and they would enter the creek below Riske's Crossing. The frequency at which these or the McCarthy Street bypasses of sewage have occurred have not been studied with regard to their impact on the creek but their intermittent nature may preclude the quantification of the impacts. Nevertheless, these discharges, particularly those from the primary plant, certainly add to the bacterial population of the creek.

3.3.1.4 Treatment/Disinfection Failures

Chlorination and/or alum treatment and filtration failures at the tertiary plant occur intermittently.

Such events may directly account for the occasional high indicator bacteria levels observed in the effluent (e.g. Tables 3.2, 3.3, 3.4.1, 3.4.2) and partially or indirectly for those observed at Sidmar Crossing (e.g. Tables 3.2, 3.3, 3.4.5). Such events also may contribute to the passage of pathogenic bacteria and viruses of human origin into the creek.

3.3.1.5 Animal Feces

Wildlife and waterfowl may also contribute indicator bacteria and/or pathogenic microbes to the creek either directly or indirectly via washing in of feces from the watershed. In a similar manner, livestock operations along the creek may make similar contributions of bacteria which, because they may be diffuse inputs, cannot readily be controlled.

3.3.1.6 Growth/Regrowth of Indicator Bacteria

Growth of coliform species and coliform-like bacteria, particularly during periods of warm water temperatures, may readily explain the elevated indicator bacteria levels along the creek and river reach and the lack of decline in levels (e.g. Figures 3.2.1 - 3.2.4) with distance from the effluent source in July and August, 1982. Temperature alone,

however, does not control bacterial growth and the nutrient loading attributable to the municipal effluent (Tones 1981) may be considered as a major indirect contributor to the observed high levels of indicator bacteria. In the following passage, this subject is considered in greater detail and possible means of determining the significance of growth or regrowth of indicator bacteria in the creek are discussed.

3.3.1.7 Contributions from Moose Jaw

There is also a potential for some of the elevated indicator bacteria levels observed on the Qu'Appelle River to be partly attributable to contributions of sewage from the City of Moose Jaw. The potential impact may be greatly reduced or eliminated by the use of all effluent by that municipality for irrigation purposes.

3.3.1.8 Sanitary/Storm Sewer Cross Connections

Cross connections between the sanitary and storm sewer pipes may provide a means by which intermittent slugs of feces and bacteria are discharged from the urban area of Regina to the creek. Direct cross connections or combined sewers in older areas of the

city may not be common but there may exist numerous households in which toilets, showers and sinks may be connected to storm sewer rather than sanitary sewer lines. Though the relatively small amounts of sewage added to the storm sewer pipes may not be sufficient to cause detectable flows, the accumulated feces and wastewater in the storm pipes are themselves sources of enormous numbers of indicator bacteria and may provide nutrients for proliferation of these and other bacteria in the underground pipeline environment. Runoff events or activities involving much smaller volumes of water (e.g. street washing, swimming pool drainage, vehicle washing, excessive lawn watering, etc.) that may be discharged into the storm sewers may cause the accumulated fecal sewage to be washed into the creek or drainage canal.

Bacteriological contamination due to these causes cannot be readily pinpointed as to origin because of their intermittent nature and relatively unpredictable occurrence. The elimination of cross connections, if they exist, and elimination of connection of toilets and other domestic waste basins to the storm sewer system may be a means of reducing fecal contamination of the creek within the urban area of Regina. In this instance, as is the case

with the other probable sources mentioned above, the intermittent and unpredictable nature of the bacterial/fecal inputs, together with the apparent higher variability in the indicator bacteria data, make it unlikely that downstream water quality can reliably be associated with known events upstream.

The City of Regina has undertaken surveys of cross-connections in residential areas since 1977. The presence of cross-connections and improper connections were confirmed in several areas and many of these have been corrected. Further surveys are apparently being conducted to continually identify and correct improper connections to the sanitary and storm water systems in the City.

Species identification of isolated colonies or cultures presumed to be TC or FC would help to resolve the question of the relevance of the coliforms as an indicator of pollution of the creek and river by human and/or animal feces. In many instances, surface water analyses for TC, in particular, may be subject to interference by non-enteric species which, in the sense of their origins, are not "coliforms." Aeromonas hydrophila is one such species which mimics TC in biochemical

reactions but is a naturally occurring bacterium which proliferates in nutrient-enriched waters and is rarely isolated from human feces. A. hydrophila, however, proliferates in waters contaminated with sewage effluents. Although it is not likely a suitable indicator of fecal pollution, it nevertheless is itself of significance to health of humans (Trust and Chipman 1979), cattle (Wohlgemuth, Pierce and Kirkbride 1972) and aquatic animals.

Similarly, the proliferation in water of species which would be considered "coliforms" by virtue of their taxonomic characteristics can also detract from the significance of observed TC levels since, under these conditions, the data would not reflect a measure of water quality that could be related directly to the impacts of known discharges of domestic or animal wastes. This phenomenon of growth or regrowth of coliforms is often observed below sewage outfalls. For instance, fecal coliform to total coliform (FC/TC) ratios of less than 0.20 have been reported to be due to aftergrowths of the enteric species Aerobacter (or Enterobacter) aerogenes (ORSANCO Water Users Committee 1971*; Lin, Evans and Beuscher 1974).

* Ohio River Valley Water Sanitation Committee

In the case of Wascana Creek and the Qu'Appelle River during the months of July and August, 1982, there were only two stations for which FC/TC ratios were found to exceed 0.20 (Table 3.5.3). If this suggested relationship between FC and TC is valid,then most stations along the creek and river could be said to have been subject to proliferations of E. aerogenes which caused TC levels to rise well above acceptable levels. There is little scientific evidence to support the validity of this suggested FC/TC relationship. As described for the FC/FS ratio, this suggested FC/TC relationship may be subject to severe interferences and would require extensive applied research to verify its significance. It is presented here only to demonstrate another application of a suggested mathematical relationship between arbitrarily defined groups of bacteria in surface waters. Like the FC/FS ratio, its significance must be very carefully evaluated.

One final point that must be considered due to its potential significance to water quality determinations in general is the influence of high numbers of non-coliform or background bacteria on the

Table 3.5.3

Ratios of geometric mean values of fecal coliform (FC) to total coliform (TC) determined by different analytical procedures for samples collected along Wascana Creek and Qu'Appelle River in July and August, 1982

Sampling Station	Analytical Procedure					
	MF (no./100 ml)			MPN (no./100 ml)		
	FC	TC	FC/TC	FC	TC	FC/TC
Wascana Creek						
Riske's Crossing	42.6	1251.3	0.03	110.6	602.6	0.18
Regina STP	32.1	210.7	0.15	114.1	536.7	0.21
Sidmar Crossing	53.8	7755.6	0.01	109.3	5215.5	0.02
Hungry Hollow	78.0	2908.4	0.03	149.4	1350.0	0.11
Old Crossing	--	--	--	--	--	--
Battered Bridge	--	--	--	--	--	--
Above Qu'Appelle River	53.5	1250.4	0.04	97.8	2312.9	0.04
Qu'Appelle River						
Above Wascana Creek	70.4	1264.0	0.06	186.3	601.4	0.31
No. 11 Highway	73.3	2392.0	0.03	324.7	1703.7	0.19
Market Gardens	28.7	901.9	0.03	54.7	337.8	0.16

MF - membrane filtration
MPN - most-probable-number

enumeration of TC and FC bacteria. In the determination of TC by the MF procedure, no more than 200 total colonies should be present on the membrane filter and the TC colony count should be between 20 and 80 colonies. In summer, in Wascana Creek and in other enriched surface waters, these counting ranges were rarely observed (Dr. J. Bergman personal communication) and TC colonies, and in many cases FC colonies, must be enumerated among excessively high levels of other bacterial colonies. Such interferences are less obvious with the MPN procedures for TC and FC as individual colonies are not enumerated. However, there was general agreement between the geometric mean data for July and August,1982 MF and MPN determinations (Figures 3.2.1 - 3.2.4). TC data for the creek for the summer periods, therefore, may not necessarily provide an accurate picture of the coliform populations in the water. This is one reason that there is growing disuse of the TC group for surface water quality assessment (E. E. Geldreich personal communication). As discussed above, species identification would help resolve the nature or origins of observed coliform bacteria. The elimination of interfering background or non-coliform

species would require media development to provide a more selective and specific "coliform" enumeration procedure than currently exists.

3.3.2 Sanitary Conditions

While the foregoing sections have described the waters of Wascana Creek and portions of the Qu'Appelle River as having exceeded some of the provincial water quality objectives during the summer of 1982, the general sanitary conditions of the creek and river should also be considered in evaluating the water's suitability for various uses.

Wascana Creek serves as the receiving water body for sewage effluent from the City of Regina. The contribution of effluent from the sewage treatment plant to total flows in Wascana Creek and the Qu'Appelle River are summarized in Table 3.5.4. This table is simplified somewhat in that sewage which bypasses the tertiary plant and enters the creek directly as during storm events is not identified as effluent, but rather, is seen only as part of total flows. (Data are currently not available to accurately depict how much bypasses the tertiary

Table 3.5.4

Average total monthly discharges - 1978 to 1982

	Sewage Treatment Plant - Tertiary Outfall Flow[1] (dam^3)	Wascana Creek above Confluence with Qu'Appelle River		Qu'Appelle River below Confluence with Wascana Creek	
		Flow[2] (dam^3)	Effluent Contrib. (%)	Flow[2] (dam^3)	Effluent Contrib. (%)
January	1 805	1 103	163.6	2 998	60.2
February	1 579	1 034	152.7	2 778	56.8
March	1 903	2 243	84.8	5 721	33.3
April	2 026	31 100	6.5	69 185	2.9
May	2 206	11 224	19.7	45 997	4.8
June	2 124	2 912	72.9	13 277	16.0
July	2 208	3 117	70.8	13 951	15.8
August	2 004	2 334	85.9	8 846	22.7
September	1 910	2 117	90.2	5 151	37.1
October	1 579	1 998	79.0	4 432	35.6
November	1 365	1 268	107.6	3 266	41.8
December	1 824	1 121	162.7	3 252	56.1

1 File data provided to Saskatchewan Environment by the City of Regina.

2 Water Survey of Canada data.

plant in any designated time period.) Also, it is assumed that all effluent leaving the treatment plant arrives at the recording stations on Wascana Creek and the Qu'Appelle River.

Data for Wascana Creek for the winter period, November to March, are of limited use as effluents may enter the water column, or may flow over and form additional ice cover. No flow information is available for the creek for the area immediately upstream of the sewage treatment plant and it is therefore not possible to confirm the contribution of effluent to streamflows in the winter. For these same reasons, winter data for the Qu'Appelle River are also questionable.

For the period April to October (roughly equivalent to the open-water season) it can be seen that effluents from the sewage treatment plant form a large part of the flow in Wascana Creek, and a fairly high percentage of flows in the Qu'Appelle River. As would be expected, plant effluents contribute least to total flows during the period of spring runoff, and most during the latter summer and fall months

when naturally-occurring flows are at their lowest rates.

From the sanitary standpoint this suggests an increased potential for the transmission of pathogenic microbes to crops irrigated during the summer when natural flows are low. It also suggests a considerably greater risk of transmission of pathogenic microbes to cattle watered during the winter when disinfection of the municipal sewage effluent is not carried out.

3.4 Potential Health Concerns

Since direct contact recreation and consumptive uses of the waters of Wascana Creek and Qu'Appelle River by humans are not apparent, the main concerns over the observed high levels of indicator bacteria (Appendix 2) are that they suggest the possibility of the presence of pathogenic bacteria in water used for vegetable crop irrigation. Despite the limitations of the TC concept concerning its use to assess recreational water quality (Dutka 1973), the exceedance of surface water quality objectives for FC during July and August, 1982 (Table 3.4.3) provide a much stronger indication of the potential for pathogenic microbes along the creek and river reach downstream of Regina in areas where extensive crop irrigation is practiced.

However, epidemiological evidence is very weak with regard to waterborne disease resulting from the consumption of vegetables irrigated with surface waters of marginal or poor quality such as that observed for the creek and river in July and August, 1982. The potential for viruses to survive on vegetables irrigated with treated/disinfected sewage effluent has been demonstrated (Kott and Fishelson 1974; Smith et al 1983).

In any surface water there is the potential for the presence of pathogenic microbes be they derived from human sewage, from wild or domestic animals, or from the naturally occurring population of microbes which grow in the aquatic environment (e.g. Listeria, Yersinia, Legionella). The bacterial indicators were not developed in relation to the presence of these non-salmonellae genera or viruses. Therefore, there can be assumed to be some risk with the use of untreated surface water for the watering of vegetables which may be consumed without benefit of cooking (e.g. cauliflower, cabbage, lettuce, carrots, tomatoes, broccoli, etc.) whether or not high levels of indicator bacteria are observed. This risk must be assumed to increase as the incidence and degree of fecal contamination of the water increases or as the population of pathogenic microbes is increased due to an enrichment of the aquatic environment which favours the

survival or growth of the pathogens (e.g. Geldreich 1983).

Livestock may be susceptible to diseases or subclinical conditions resulting from the ingestion of contaminated water but there is poor epidemiological information upon which an indicator bacteriological water quality objective for livestock watering might be set. Paratyphoid has occurred in dairy cattle, for instance, due to cattle watering on a surface water contaminated with village sewage effluent (e.g. George et al 1972) but surface water quality relationships between the waterborne pathogen and indicator bacteria have not been established. Fecal contamination of waters by sewage effluents, however, is noted as one factor of contributing to the maintenance of salmonellae-related disease and carrier states in man and animals (e.g. Edel et al 1973). Therefore, while quantitatively the significance of indicator bacteria to the livestock watering use potential of a water body may not be determined easily at present, good management practices should indicate that watering with poor quality water increases the risk of illness among livestock and/or may contribute to a growing reservoir of pathogenic microbes in the farm and wild animal populations.

On Wascana Creek, livestock watering occurs year round. This involves watering during winter months when Regina's effluent

is not disinfected and a greater proportion of water in the creek may be effluent. (Table 3.5.4)

Wascana Creek and portions of the Qu'Appelle River during the primary irrigation use period certainly must be concluded to be of generally poor water quality. The risk to health of consumers of raw vegetables irrigated with this water, however, cannot accurately be quantitatively determined or assessed by determining coliform (TC, FC) levels. The determination of pathogens (e.g. salmonellae) in the water at use areas (Figure 3.1) may provide a better measure of the risk to health associated with raw vegetable consumption but even this risk assessment cannot be quantified. Technical limitations of the isolation procedures and lack of epidemiological information preclude a quantitative risk evaluation. Furthermore, the pathogen (salmonellae) isolation procedures available do not provide a reliable means of detection of these pathogens so that negative results cannot be assumed to necessarily indicate the absence of salmonellae or other pathogens (viruses, parasites) in water or on irrigated vegetables. An additional study of the microbiological characteristics of the creek and river emphasizing the detection of pathogenic bacteria and viruses in water and on irrigated vegetables may provide confirmatory evidence of potential health concerns or lack of concerns

related to irrigation of vegetables to be consumed. Quantitative risk determination, however, is unlikely. Also, because of the potential for contributions of salmonellae and other microbes from non-point sources (waterfowl, storm sewers, sedimentary reservoirs, cattle, wildlife) the determination of the origin of specific microbes (species, genera) would be difficult or impossible to determine without extensive serological and taxonomic characterization of the isolates. In summary, as noted for the indicator groups (TC, FC, FS) (Section 3.3.2), the detection of pathogens in the creek and river may be of assistance in determining the suitability of the water quality characteristics of these water bodies for irrigation of vegetable crops but the relative contributions of the sewage effluent and other known or likely sources of bacteria related to water use downstream cannot readily be determined.

In most years in summer, except perhaps immediately following significant rainfalls, there is relatively little flow in Wascana Creek. (Table 3.5.4). Normally then, effluent discharged from the Regina tertiary treatment plant comprises a significant volume of the water in the creek. Because of the intermittent poor quality of this effluent and the likelihood of intermittent releases of pathogens in the effluent, the sewage effluent discharged in summer must be

considered one likely source of indicator bacteria and of pathogens which contribute to an increased risk of introducing pathogens to vegetables irrigated with the contaminated water.

The effluent may also indirectly contribute to the poor bacteriological quality of the water by providing nutrients (e.g. Tones 1981) which permit longer survival, and recovery of chlorine injured bacteria discharged in the effluent. It may also contribute to the proliferation of naturally occurring aquatic microbes, some of which may be pathogenic to man or animals.

Health risks related to the consumption of raw vegetables irrigated with water from Wascana Creek and portions of the Qu'Appelle River for the July/August 1982 period can therefore not be estimated with current information.

At present, the available information based upon total coliform data of questionable significance and upon fecal coliform and fecal streptococci data of more credible value indicates the water in the creek to have been generally unsuitable for vegetable crop irrigation in terms of the province's existing bacteriological surface water quality objectives. The known limitations of the indicator concepts (Section 3.3; Bonde 1977) and the apparent absence of

epidemiological evidence of human or animal illness related directly (e.g. consumption, recreational) or indirectly (raw vegetable consumption) to the poor bacteriological quality of surface waters creates a dilemma which, for decades, has gone unresolved. That is whether the surface water quality objectives, based upon essentially arbitrary indicator bacterial concepts, are correct and/or if current awareness of disease occurrence related directly or indirectly to creek and river water quality is sufficient to determine a cause and effect relationship between indicator bacterial levels, incidence of pathogens, and occurrence of disease among water users and vegetable consumers.

In summary, epidemiological evidence generally is lacking with regard to water quality guideline or objective levels of TC, FC or FS bacteria. It is virtually non-existent with regard to the specific situations regarding consumption of raw vegetables which had been irrigated with water of poor indicator bacteria quality.

4.0 Summary

A recent Water Pollution Control Branch report (Tones 1981) described the historical bacteriological water quality of Wascana Creek and a portion of the Qu'Appelle River to be unsuitable in summer for direct contact recreation or for vegetable crop irrigation. In a follow-up to the 1981 report, the branch conducted a survey of water users along the creek and river late in 1981 to determine the types and locations of water use. Subsequently, the branch conducted intensive bacteriological monitoring of the creek and river during the period of July and August, 1982, when the major use of the waters occurs.

The major uses of the creek and river water were generally restricted to the summer months and included forage crop irrigation, livestock watering and irrigation of both private and market garden vegetables. A total of 62 water users were identified between Riske's Crossing on Wascana Creek and the Market Garden site on the Qu'Appelle River (Figure 3.1) with 28 of these involved in private or commercial vegetable crop irrigation. Seventeen other users watered cattle, horses and/or sheep along the creek and river, some on a year-round basis.

No human consumptive or direct contact recreational uses of the creek and river were identified.

A review of historical flow data for the creek and river and of municipal effluent discharges indicated that during low flow periods (e.g. summer, winter) flows in the creek and river may be significantly comprised of sewage effluent (Table 3.5.4).

There are surface water quality objectives in Saskatchewan with regard to bacteriological water quality and for water uses including consumptive water supply, direct and non-contact recreation and vegetable crop irrigation. The existing objectives pertain only to the indicator groups total coliforms (TC) and fecal coliforms (FC).

Compared to Saskatchewan's objectives regarding geometric mean values of TC observed over the July/August, 1982 period, the creek and river water quality was generally unsuitable for vegetable crop irrigation or for contact recreation. A similar finding was reported by Tones (1981) in a review of historical data. Considerable variability in the data concerning individual samples was observed, particularly for the tertiary plant effluent which is usually disinfected by chlorination during this period. Individual values for TC in the effluent site were as high as 240,000 TC per 100 ml indicating intermittent failures in disinfection processes. However, the coliform (TC) geometric mean value for the effluent in July/August, 1982, tended to be less than that observed at most

other stations on the creek and river. This does not suggest consistently good effluent quality but rather the influence of the chlorination treatment (reducing indicator bacteria to negligible levels with periodic lapses) upon the observed bacterial levels in the effluent (Figures 3.2.1, 3.2.2), and the statistical analyses of the observed results.

Geometric mean values for FC were generally within the objective level for this indicator bacteria group (Figures 3.2.3, 3.2.4). This would suggest the water to be acceptable or, at worst, marginal, as a source of water for vegetable crop irrigation or for other uses along the creek and river.

Fecal streptococci (FS) geometric mean levels were consistently above guideline levels previously suggested for irrigation or livestock watering in another jurisdiction (Ontario Ministry of the Environment 1970) at all sampling sites above and below the tertiary sewage effluent outfall. This objective has however been withdrawn by Ontario.

When other Saskatchewan surface water quality objectives, (based upon frequency of exceedance of specific indicator bacteria levels in samples collected monthly or on a daily basis), regarding indicator bacteria (TC, FC) were used to evaluate the July/August data there was general exceedance of the objectives for both TC and

FC at nearly all sampling sites (Tables 3.4.1-3.4.4).

An assessment of the data for the Sidmar Crossing in Wascana Creek and the conditions on the operating approval of the City of Regina tertiary treatment plant was undertaken. In July and August of 1982, 75 per cent of the samples taken at Sidmar Crossing contained TC at levels above the prescribed level of 5,000 TC per 100 ml (Table 3.4.5).

Although the current study was not designed to identify the sources of bacterial contamination of the creek and river, the potential sources were discussed in the report. These included: contributions of fecal matter from wildlife, cattle, waterfowl, sediment resuspension, urban storm water, cross connections between sanitary and storm sewers, surface runoff, intermittent lapses or failures in sewage treatment or disinfection; and growth or regrowth of bacteria in the creek and river.

An analyses of the FC/FS ratio did not provide an indication as to the animal and/or human origin of the perceived high indicator bacteria populations at the effluent station or at any other sampling site. A discussion of the limitations of the indicator systems and the significance of FC/FS ratio was conducted as part of the report. The FC/FS ratio was considered likely of limited

value in the interpretation of data for Wascana Creek and the Qu'Appelle River.

In any surface water there is the potential for the presence of pathogenic microbes be they derived from the naturally occurring population of microbes which grow in the aquatic environment, from human sewage, or from wild or domestic animals.

The overall findings of the monitoring of the creek, river and City sewage discharge in this study indicate that bacteriological water quality objectives for irrigation of vegetable crops are at times exceeded and that there are periodic deficiencies in the disinfection of the effluent. This does not necessarily mean that use of the water for irrigation of vegetable crops is unsafe.

Epidemiological evidence of disease is very weak with regard to waterborne disease resulting from the consumption of vegetables irrigated with surface water of poor quality such as that observed for the creek and river in July and August, 1982.

Recommendations are made to improve the sewage disinfection and to conduct tests on the vegetables regarding the safety of the irrigation water.

5.0 Recommendations

1. Further intensive studies of the distribution of indicator bacteria in Wascana Creek and Qu'Appelle River are not recommended since such studies would likely only reconfirm the generally unacceptable bacteriological quality of the creek and river in terms of the current water quality objectives for recreational or vegetable crop irrigation uses.

   If further studies are considered necessary, they should concentrate upon the identification of point sources (sewer and effluent outfalls) and diffuse inputs (wildlife, runoff) of bacteria and particularly upon the isolation and identification of enteric bacteria, pathogenic species, and viruses and parasites of probable health concern. These latter studies should be carried out with regard to the sewage effluent, creek and river water, and vegetables irrigated with the water. Similar microbial characterization of the waters actually irrigated should also be carried out. Such studies would help to better define the sanitary characteristics and potential health concerns associated with the watersheds.

2. Because of the apparent poor bacteriological water quality at Riske's Crossing, the City of Regina should be requested to continue to investigate the occurrence and prevalence of improper sanitary installations and cross connections between

the sanitary and storm sewer systems in the urban area of Regina. Where significant problems of this type are confirmed corrective measures should be taken.

3. Summaries of treatment plant disinfection and treatment failures for summer periods should be prepared to determine the causes and frequency of problems which may result in releases of poor quality effluents on an intermittent basis. Corrective measures and increased diligence in disinfection procedures should form the main goals of such a summary. A back-up chlorination system should be located at the tertiary plant to increase the assurance of proper disinfection of the effluent.

4. Owing to the apparent use of creek water for year-round livestock watering (Figure 3.1) at sites just downstream of the effluent outfall collection of bacteriological data should be undertaken at the effluent discharge and at several points downstream where winter watering of livestock is practiced. Pending the outcome of this monitoring, further follow-up may be warranted.

5. The existing conditions of approval of operation regarding the Regina sewage treatment plant should be revised to eliminate the bacteriological criterion specified for Sidmar Crossing.

It is recommended that disinfection of the effluent be initiated each spring as soon as possible after ice break-up on the creek, or no later than April 15, and be continued through to October 30 of each year and that a total chlorine residual of 0.5 mg/l be maintained in the final effluent at its point of discharge after 15 minutes retention time. Furthermore, no greater than 2,400 total coliform per 100 ml or 200 fecal coliform per 100 ml should be present in any sample of the final effluent on any day that analyses are conducted during the specified period of required chlorination.

6. It is recommended that bacteriological monitoring of the final effluent at the point of discharge to Wascana Creek be carried out year-round for total and fecal coliforms and for fecal streptococci by the City of Regina as an additional operating condition. A minimum of 10 samples per month obtained on at least 5 days per month during the period November 1 to March 31 of the following year should be obtained and analyzed. During the major water use periods April 1 through October 30, 20 samples per month obtained on at least 10 days during each month should also be required to be analyzed for TC, FC and FS.

7. A study should be conducted during the 1984 growing season to determine whether disease-causing organisms (including bacteria, viruses, parasites, etc.) are present on vegetable crops grown at sites along Wascana Creek and the Qu'Appelle River. Water sampling should be conducted at the same time in order to assess the contribution of irrigation waters to the observed levels of contamination. For control purposes, produce imported to the province should be analyzed concurrently.

8. A review of existing water quality objectives for indicator bacteria with regard to various water uses should be undertaken by Saskatchewan Environment in co-operation with the provincial Departments of Health and Agriculture.

Addendum

Since completion of the 1982 study the City of Regina has implemented changes in the disinfection procedures practiced at the tertiary treatment plant. The City has also agreed to make provisions for an auxiliary chlorination unit to disinfect effluent on an emergency basis. The City has also undertaken intensive monitoring to assess the beneficial effects of the changes in chlorination practices in improving the bacteriological quality of the effluent and creek water. The initial results of this monitoring suggest that these changes in effluent disinfection may alleviate bacteriological contamination in the creek attributable to the effluent discharge.

With regard to further studies of the watersheds and irrigational use of the waters of Wascana Creek and the Qu'Appelle River, Saskatchewan Health is planning to undertake a microbiological study of the watercourses and vegetable crops irrigated with creek/river water in the Craven area in 1984.

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List of Appendices

Appendix 1 Report on water use along Wascana Creek and the Qu'Appelle River 1981/82

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Appendix 1

REPORT ON WATER USE ALONG WASCANA CREEK AND
THE QU'APPELLE RIVER 1981/82

Government of Saskatchewan

Memorandum

From Water Pollution Control Branch

Date December 17, 1981

Phone

To File

Your File

Our File F7-5-1-3

Re Wascana Creek - Qu'Appelle River Water User Survey

A telephone survey of water users located along Wascana Creek and Qu'Appelle River was conducted by W.P.C.B. staff D. D. Jeske and S. A. Ferris on December 10, 11, and 14, 1981. The following is a summary of procedures and findings of this survey.

Preliminary steps include compilation of a licenced water user list from Water Rights Branch files. A second list of all those persons owning or renting land along Wascana Creek or Qu'Appelle River watercourses with potential for private water use was prepared from Rural Municipality maps.

Potential or known water users numbering 62 were identified on these lists. Persons contacted by the Branch during this survey numbered 59. Table 1 presents a summary of information collected from 38 persons who identified themselves as water users and one person which could not be contacted but which is known to own an intensive livestock operation using water from the Qu'Appelle River. To further facilitate easy location of these operations Figure 1 pinpoints those water users identified numerically from Table 1.

Persons stating that they do not or no longer make use of this water totalled 21. Nine of these persons hold valid water use permits but do not use water from the watercourses. Two of these persons have applied for water use permits and plan to irrigate vegetable crops or lawns next year.

Identified water users were questioned further concerning the nature and details of their operations. A verification of land locations and point of diversion was sought. Persons were then questioned as to the nature of the operation being either private or commercial, and detailed descriptions of the type of use, i.e. livestock watering, mixed vegetables forage crop irrigation, etc. If water use was irrigation further questions were asked concerning the area irrigated, volume irrigated, size of pumping equipment, main periods of irrigation/use, and approximate time of the termination of irrigation prior to harvest.

In all cases land location, operation description, type of use, area irrigated, and main periods of irrigation/use were easily identified.

Volume irrigated was usually difficult to define due to the indirectly proportional relationship with rainfall. Furthermore, most of the operators were not certain of pumping capacity of their irrigation systems. As a result "as required" is recorded in the volume irrigated column. An impression of the volume of water used may be obtained if one extrapolates from the size and nature of the operation. The amount of water allocated by Water Rights Branch has been recorded where available.

When questioned concerning the time which irrigation practices cease with respect to harvest, again this parameter was not easily defined. Ground crops irrigation is generally stopped about one week prior to harvest. Above ground crops may have been irrigated until 1-2 days before harvest. Corn irrigation was ceased one month prior to harvest.

It was noted that 32 persons interviewed responded questioning the use-safety of these waters and 14 of these expressed a great deal of interest of potential corrective action. The "salty" nature of the water and observed "salt deposits" on irrigated soils was addressed in five interviews.

To summarize there are 10 small commercial livestock operations, 21 commercial and private gardening operations and 8 operations having both livestock and garden crops all using water from Wascana Creek and Qu'Appelle River.

S. A. Ferris
Water Quality Division

SAF:jak

TABLE 1: Summary of information regarding private and commercial users of water along Wascana Creek and Qu'Appelle River (Regina to Craven) in 1981

User No.	Name	Land Location(s)	Description of Information	Type of Use	Area Irrigated	Volume Irrigated	Main Periods of Irrigation/ Use	Irrigation Termination Before Harvest	Irrigation Termination After Harvest	Other Comments
1	D.J. Bramley	N½36-17-21-W2	small commercial	Horse Watering	--	--	Summer	--	--	- not licenced - horse watering on property adjacent to creek
2	C. F. Delarue	N½2-18-21-W2 S½11-18-21-W2 N½35-17-21-W2	small commercial	cattle watering	--	--	throughout year	--	--	- not licenced - cattle watering on property adjacent to creek - are considering irrigating hay crops for cattle feed, have not begun this practise
3	Anton Bistretzan	N½3-18-21-W2	small commercial	sheep watering	--	--	throughout year	--	--	- not licenced - sheep watering on property adjacent to creek
4	R A. Dunlop	NE 9-18-21	private	mixed vegetable garden lawns	<1	2-3 acre-feet	5-6 times through summer	before		- not licenced - as required by vegetables
			small commercial	cattle watering			cattle in summer			- cattle watering on property adjacent to creek
5	H. Beatty	SE17-18-21-W2	private	mixed vegetable garden and lawn	1-2	allocated 2 acre-feet exact unknown	throughout summer May to August	before 1 week		- licenced - as required by vegetables

TABLE 1: Summary of information regarding private and commercial users of water along Wascana Creek and Qu'Appelle River (Regina to Craven) in 1981

User No.	Name	Land Location(s)	Description of Information	Type of Use	Area Irrigated	Volume Irrigated	Main Periods of Irrigation/ Use	Irrigation Termination Before Harvest	Irrigation Termination After Harvest	Other Comments
6	R.A. Baker	W;21-18-21-W2	small commercial	cattle watering	--	--	summer	--	--	- not licenced - cattle watering on property adjacent to creek
7	R.G. Martin	SW28-18-21-W2	small commercial	cattle watering	--	--	summer	--	--	- not licenced - cattle watering on property adjacent to creek
8	J.K. Gilmour	SE3-19-21-W2	private	mixed vegetable	1	10,000 gal.	May to August	before 1 week	--	- not licenced
		NE 33-18-21-W2	small commercial	cattle watering	--	--	throughout the year	--	--	- cattle watering on property adjacent to creek
9	D. Thiesen	SW3-19-21-W2	private	mixed vegetable garden	1	as required	May to August	before 1 week	--	- not licenced
				lawns	--	as required	as required	--	--	- lawns and garden watered as required by rainfall conditions
				hay field	--	as required	May to October	--	--	
10	A.S. Morton	NW3-19-21-W2	small commercial	cattle watering	--	--	summer	--	--	- not licenced - cattle watering on property adjacent to creek
			rental land	mixed vegetable garden	3	as required	May to August	unknown	--	- this is land rented to others for vegetable gardening
				lawns						

TABLE 1: Summary of information regarding private and commercial users of water along Wascana Creek and Qu'Appelle River (Regina to Craven) in 1981

User No.	Name	Land Location(s)	Description of Information	Type of Use	Area Irrigated	Volume Irrigated	Main Periods of Irrigation/ Use	Irrigation Termination Before Harvest	Irrigation Termination After Harvest	Other Comments
16	G. McEwen	W½18-19-21-W2	private	mixed vegetable garden	40 acres	as required	May to August	before	--	- not licenced - garden watered as required by rainfall
		W½7-19-21-W2	private small commercial	hay field cattle watering	--		summer	--	--	- cattle watering on property adjacent to creek
17	A. McEwen	NE18-19-21-W2	commercial	potatoe & turnips	50	as required	May to August everyday	before	--	- not licenced
			small commercial	cattle watering	--	--	summer	--	--	- cattle watering on property adjacent to creek
18	I.E. Percival	SE19-19-21-W2	private	Alfalfa	7	allocated 33 acre-feet	May to Sept.	--	--	- licenced - irrigate alfalfa all day and all night Tractor powered 6" X 6" pump - 20-25 acres of alfalfa planned for irrigation next year
			private	horse watering	--	--	summer			- horse watering on property adjacent to creek
19	C. Wong & Sons	NE30-19-21-W2 SE30-19-21-W2 NE19-19-21-W2 NW29-19-21-W2	commercial	potatoe wholesale	approximately 199 acres	allocated 157 acre-feet	May to Sept.	before 1-2 weeks	--	- licenced - irrigation is dependant on rainfall

TABLE 1: Summary of information regarding private and commercial users of water along Wascana Creek and Qu'Appelle River (Regina to Craven) in 1981

User No.	Name	Land Location(s)	Description of Information	Type of Use	Area Irrigated	Volume Irrigated	Main Periods of Irrigation/ Use	Irrigation Termination Before Harvest	Irrigation Termination After Harvest	Other Comments
11	W.H. English	NW4-19-21-W2	small commercial	cattle watering	--	--	summer	--	--	- not licenced - cattle watering on property adjacent to creek
12	Hydra Ventures Ltd.	NE5-19-21-W2	private	mixed vegetable garden	1	as required	May to Sept.	before 1 week	--	- not licenced - 2" pump
				trees and lawns	--	--	as required	--	--	- lawns and gardens watered as required by rainfall conditions
13	K.W. Gaur	SW8-19-21-W2	commercial	mixed vegetable garden alfalfa field		15,840,000 gal. allocated 42 acre-feet	June-July once every 2 weeks	before	--	- licenced - waters 4 acres of land in 10 to 12 hours - 400 gal. min. 4" to 3" pump
			commercial	cattle watering	--		as required	--	--	- cattle watering on property adjacent to creek
14	L.H. Kidd	S½8-19-21-W2	small commercial	cattle watering	--	--	as required all year	--	--	- not licenced - cattle watering on property adjacent to creek
15	R. Kidd	SE18-19-21-W2	small commercial	cattle watering	--	--	as required all year	--	--	- not licenced - cattle watering on property adjacent to creek

TABLE 1: Summary of information regarding private and commercial users of water along Wascana Creek and Qu'Appelle River (Regina to Craven) in 1981

User No.	Name	Land Location(s)	Description of Information	Type of Use	Area Irrigated	Volume Irrigated	Main Periods of Irrigation/ Use	Irrigation Termination Before Harvest	Irrigation Termination After Harvest	Other Comments
20	D. Gauer	SW30-19-21-W2	commercial wholesale	potatoe	40	every 2½ weeks	May to Sept.	before 1 weeks	--	- not licenced - irrigation is dependant on rainfall
			private small commercial	hay cattle watering	35 --	as required --	May to Sept. summer and fall			- cattle watering on property adjacent to creek
21	D.C. Cowely	NW30-19-21-W2	commercial market garden	mixed vegetables garden	20	as required allocated 24 acre-feet	May - Mid September	before - some 1-2 days - some 1 week	--	- licenced user - irrigation dependant on rainfall
22	A. Duncan	SE31-19-21-W2	commercial wholesale	potatoes only	52	as required	June - Mid September	before at least 2 weeks	--	- not licenced - irrigation dependant on rainfall
23	I. McDougall	SE32-19-21-W2	commercial	potatoes cabbage rutabaga	25 5 5	twice/year as requested 1 in spring	May to Sept. May to Sept. May to Sept.	before 1-2 weeks before 1-2 weeks before 1-2 weeks	--	- not licenced - irrigation dependant on rainfall
24	J.S. Rootman	NW33-19-21-W2	commercial wholesale	mixed vegetable garden	90	as required allowed 34 acre-feet	May to Sept.	before - some 1-2 days - some 1 week		- licenced - irrigation dependant on rainfall

TABLE 1: Summary of information regarding private and commercial users of water along Wascana Creek and Qu'Appelle River (Regina to Craven) in 1981

User No.	Name	Land Location(s)	Description of Information	Type of Use	Area Irrigated	Volume Irrigated	Main Periods of Irrigation/ Use	Irrigation Termination		Other Comments
								Before Harvest	After Harvest	
25	H.A. Childs	SE4-20-21-W2	private	garden lawns	1	as required allocated 6 acre-feet	summer months	before	--	- licenced - irrigation dependant on rainfall - once was a commercial vegetable operation. This land (9 acres) is oats with no irrigation
26	J.W. Keirl	NE34-19-21-W2 SE3-20-21-W2	commercial wholesale	corn	50 total	as required allocated 8 acre-feet	Mid May to July	before at least 1 month	--	- licence used - irrigation dependant on rainfall
27	B. Nye	SW3-20-21-W2	commercial	mixed vegetable crops	33	as required allowed 14 acre-feet	Mid May to mid Sept.	before 1 week	--	- licenced user - irrigation dependant on rainfall
28	E. Kluge	SW3-20-21-W2	private	mixed vegetables potatoes etc.	6	as required	May to Sept.	before 1 day to 1 week	--	- not licenced - irrigation dependant on rainfall
29	E.J. Wolf	NW3-20-21-W2	private	mixed vegetable garden lawns	1	as required allocated 25 acre-feet	May to Sept.	before and during harvest	--	- licenced user - irrigation dependant on rainfall
30	G. Williamson	NE3-20-21-W2	private	mixed vegetable garden lawn	4	as required 4 acre-feet	May to July	before 1 day to 1 week	--	- licenced user - irrigation dependant on rainfall

TABLE 1: Summary of information regarding private and commercial users of water along Wascana Creek and Qu'Appelle River (Regina to Craven) in 1981

User No.	Name	Land Location(s)	Description of Information	Type of Use	Area Irrigated	Volume Irrigated	Main Periods of Irrigation/ Use	Irrigation Termination Before Harvest	Irrigation Termination After Harvest	Other Comments
31	C.E. Wolf	NE3-20-21-W2	commercial and private	mixed vegetable crops lawn	55 to 60	as required allocated 27 acre-feet	May to Sept. late fall for private garden and lawns	before 1 day to 1 week	--	- licenced user - irrigation dependant on rainfall
32	L. Anticknap	SW11-20-21-W2	commercial market garden	all mixed vegetable crops	35 (4 locations)	as required allocated 11 acre-feet	Mid April to mid October	before 1 week	--	- licenced user - irrigation dependant on rainfall
33	C.G. Weir	NW11-20-21-W2	small commercial	cattle watering	--	--	through year	--	--	- licenced user - cattle watering on property adjacent to river
				hay irrigation	30	15 acre-ft.	April-May	--	--	- diverts river water in spring to flood hay lands
34	P. Mushynsky	NW11-20-21-W2	commercial	all mixed vegetable crops	13	as requested allocated 3 acre-feet	June to Aug.	before 1 day to 1 week	--	- licenced user - irrigation dependant on rainfall
35	B.M. Patterson	NE11-20-21-W2 NW11-20-21-W2	commercial	cattle watering	--	--	through year	--	--	- licenced ILO user - cattle watering on property adjacent to river

TABLE 1: Summary of information regarding private and commercial users of water along Wascana Creek and Qu'Appelle River (Regina to Craven) in 1981

User No.	Name	Land Location(s)	Description of Information	Type of Use	Area Irrigated	Volume Irrigated	Main Periods of Irrigation/ Use	Irrigation Termination		Other Comments
								Before Harvest	After Harvest	
16	E.T. Wolfe	SE14-20-21-W2	private	mixed vegetable garden	1	as required	May to Sept.	Before 1 Week	--	- not licenced - irrigation dependant on rainfall.
17	D.B. Glenow	NW11-20-21-W2 NE14-20-21-W2 SE31-19-21-W2	commercial wholesale	mixed vegetable garden	approx. 160	as required	Mid April to End Sept.	Before 1 day to 1 Week	--	- licenced user - irrigation dependant on rainfall.
18	H. Anticknap	SE14-20-21-W2	commercial	mixed vegetable garden	4	as required allocated 9 acre-feet	May to Mid-September	Before 1 Week	--	- licenced user - irrigation dependant on rainfall.
19	J. Langford	N½13-20-21-W2	commercial	mixed vegetable garden	25	as required	May to Mid-September	Before 1 Week	--	- licenced user - irrigation dependant on rainfall.
				hay	--	----	May-June	--	--	

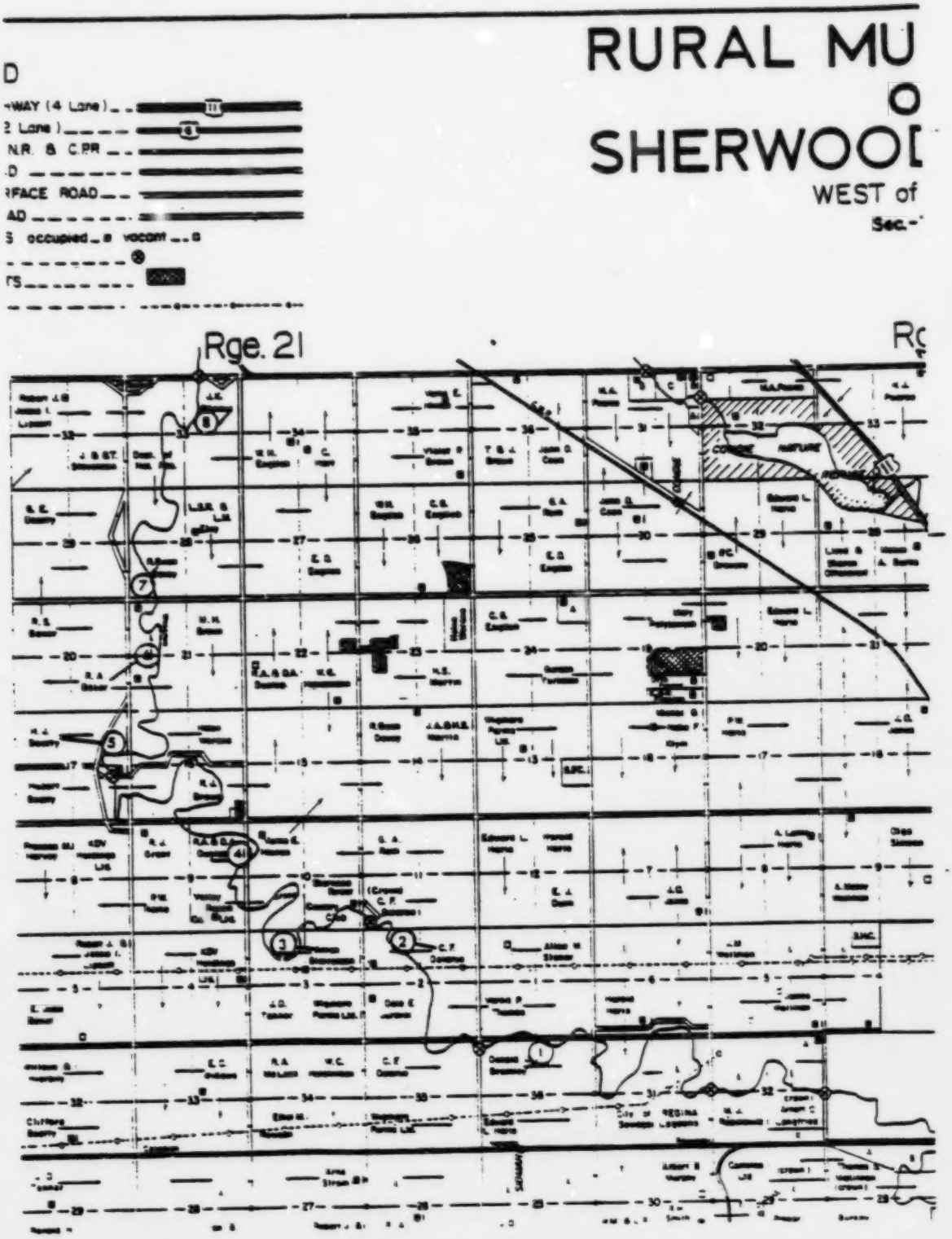

Figure 1: Locations of Wascana-Qu'Appelle Water Users (part 1)

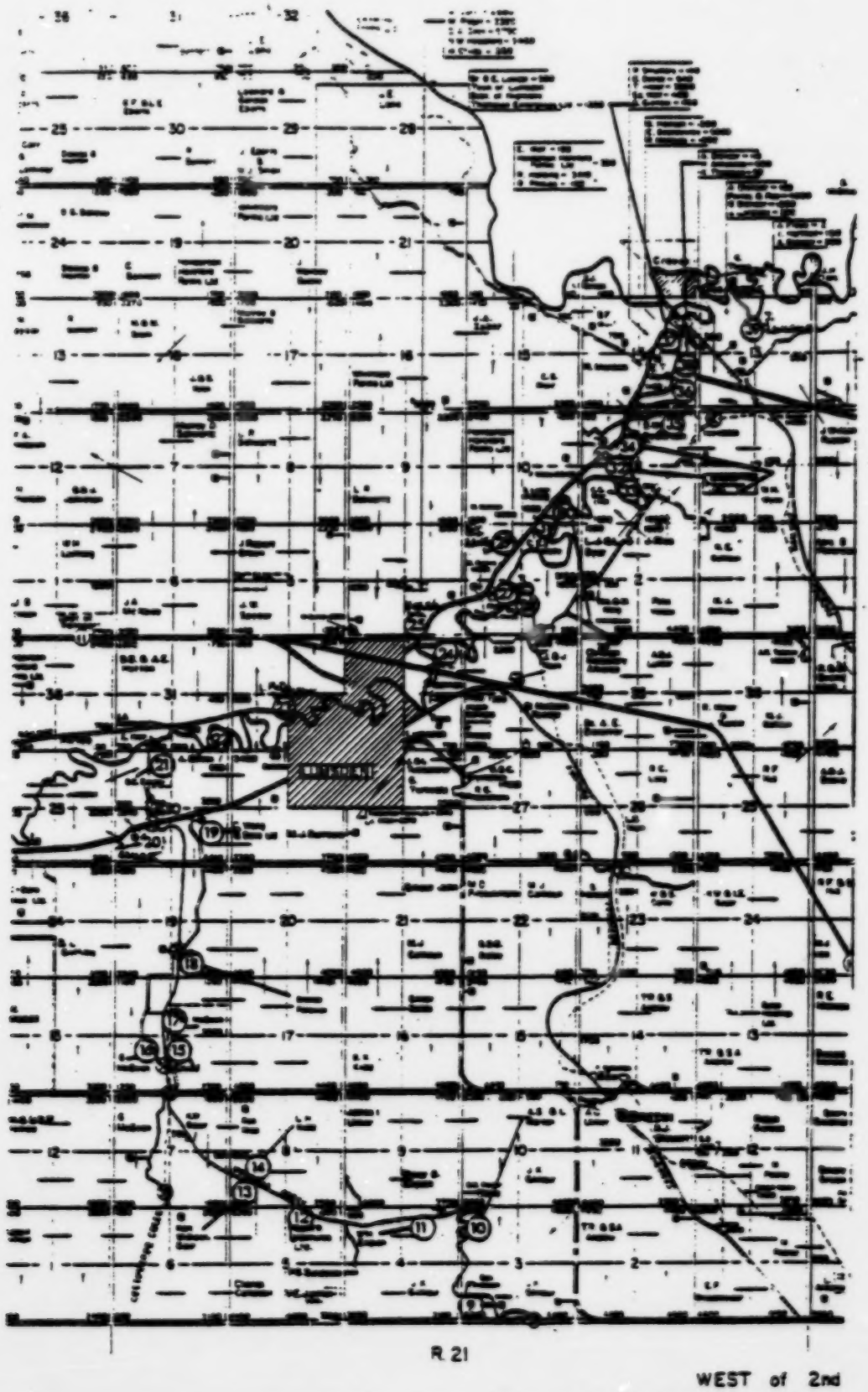

Figure 1: Locations of Wascana-Qu'Appelle Water Users (part 2)

Appendix 2

DETAILED PRINTOUT OF BACTERIOLOGICAL DATA FOR
WATER QUALITY MONITORING OF WASCANA CREEK AND THE
QU'APPELLE RIVER IN JULY AND AUGUST, 1982

STATION 05SK05130012 LAT. 50D 25M 45S LONG. 104D 36M 10S PR 5 UTM 00 396200E 5587200N

WASCANA CREEK AT PROAD STREET BRIDGE IN REGINA

SAMPLE DATE D	M	Y	CST HR	SUBM ID	36002L COLIFORMS TOTAL MF NO/100ML	36012L COLIFORMS FECAL MF NO/100ML	36102L STREP. FECAL MF NO/100ML	36001L COLIFORMS TOTAL MPN NO/100ML	36000L COLIFORMS TOTAL MPN NO/ML	36011L COLIFORMS FECAL MPN NO/100ML	36010L COLIFORMS FECAL MPN NO/ML
20	07	82	1230	0001	L100.	L10.	30.	40.		L23.	
26	07	82	1150	0001	90.	22.	160.	L30.		L30.	
27	07	82	1130	0001	20.	4.	40.	90.		L30.	
03	08	82	1035	0001	0240.	4.	70.	L30.		230.	
04	08	82	1215	0001	0100.	110.	60.	230.		L30.	
10	08	82	1200	0001	220.	16.	80.	90.		90.	

PARAMETER VALUE CODES

E...ESTIMATED VALUE
H...EXCEEDS VALIDATION LIMITS
K...INSUFFICIENT SAMPLE
N...INTERFERENCE
P...RESULT QUESTIONABLE AND POOR BLANK DEPLETION
Q...RESULT QUESTIONABLE
R...POOR DEPLETION IN THE BLANK
S...LABORATORY ACCIDENT
T...SAMPLE CONTAINER BROKEN IN TRANSIT
U...RESULTS APPEAR ERRONEOUS
9999....DATA NOT VERIFIED
V...SUSPECTED SAMPLE CONTAMINATION
W...INACCURATE RESULTS DUE TO SAMPLE AGE
X...NOT COMPLETED DUE TO LACK OF LABORATORY CAPACITY
Y...VERIFIED RESULT
Z...MACHINE MALFUNCTION

ESQUADAT DETAILED REPORT

STATION 05SK05130003 LAT. 50D 28M 34S LONG. 104D 43M 56S PR 3 UTM 00 395450E 5592400N

WASCANA CREEK, WISKEY'S CROSSING - DIRT ROAD ADJACENT TO EAST SIDE OF REGINA
LAGOON - SAMPLE DOWNSTREAM SIDE OF BRIDGE AT MIDSTREAM

SAMPLE DATE D	M	CST Y	HR	SURM ID	36002L COLIFORMS TOTAL MF NO/100ML	36012L COLIFORMS FECAL MF NO/100ML	36102L STREP. FECAL MF NO/100ML	36001L COLIFORMS TOTAL MPN NO/100ML	36000L COLIFORMS TOTAL MPN NO/ML	36011L COLIFORMS FECAL MPN NO/100ML	36010L COLIFORMS FECAL MPN NO/ML
05	07	82	0910	R001	900.	190.	100.	4600.		930.	
05	07	82	0915	R001	3600.	200.	70.	1500.		90.	
06	07	82	1230	R001	4000.	110.	120.	2300.		430.	
06	07	82	1215	R001	3200.	100.	100.	2300.		430.	
12	07	82	0815	9999	500.	30.	110.	210.		150.	
13	07	82	0845	9999	L100.	30.	70.	230.		90.	
19	07	82	0830	R001	900.	950.	50.	930.		430.	
19	07	82	0835	R001	500.	270.	110.	2400.		430.	
20	07	82	0855	R001	1200.	70.	50.	[illegible]		[illegible]	
26	07	82	0830	R001	2400.	250.	92.	4300.		140.	
26	07	82	1510	R001	2000.	430.	80.	430.		430.	
26	07	82	1925	R001	2000.	150.	108.	[illegible]		[illegible]	
27	07	82	0810	R001	2000.	380.	180.	23000.		90.	
27	07	82	1500	R001	700.	88.	92.	930.		90.	
27	07	82	1945	R001	700.	24.	36.	90.		L30.	
03	08	82	1100	R001	1000.	12.	16.	230.		L30.	
03	08	82	1500	R001	700.	10.	16.	230.		40.	
03	08	82	1505	R001	40.	4.	8.	90.		90.	
03	08	82	2000	R001	1000.	12.	48.	230.		L30.	
04	08	82	0900	R001	200.	10.	32.	930.		230.	
04	08	82	0903	R001	400.	110.	32.	150.		L30.	
09	08	82	0830	R001	4000.	8.	32.	430.		L30.	
09	08	82	0832	R001	8000.	10.	20.	2400.		L30.	
09	08	82	1500	R001	800.	8.	48.	430.		L30.	
09	08	82	1920	R001	3000.	4.	20.	2400.		L30.	
10	08	82	1015	R001	3000.	28.	8	430.		L30.	
10	08	82	1017	R001	700.	130.	84.	930.		40.	
10	08	82	1540	R001	1300.	8.	36.	90.		L30.	
10	08	82	1930	R001	300.	12.	20.	240.		L30.	
16	08	82	0845	R001	8000.	57.	230.	2300.		40.	
17	08	82	0812	R001	1000.	20.	220.	930.		90.	
23	08	82	0810	R001	11000.	180.	840.	9300.		930.	

PARAMETER VALUE CODES

L...ESTIMATED VALUE
M...EXCEEDS VALIDATION LIMITS
K...INSUFFICIENT SAMPLE
N...INTERFERENCE
P...RESULT QUESTIONABLE AND POOR BLANK DEPLETION
Q...RESULT QUESTIONABLE
R...POOR DEPLETION IN THE BLANK
S...LABORATORY ACCIDENT
T...SAMPLE CONTAINER BROKEN IN TRANSIT
U...RESULTS APPEAR ERRONEOUS
9999....DATA NOT VERIFIED
V...SUSPECTED SAMPLE CONTAMINATION
W...INACCURATE RESULTS DUE TO SAMPLE AGE
X...NOT COMPLETED DUE TO LACK OF LABORATORY CAPACITY
Y...VERIFIED RESULT
Z...MACHINE MALFUNCTION

STATION 0090450130003 LAT. 50D 28M 34S LONG. 104D 43M 56S PR 3 UTM 00 395450E 5592400N

WASCANA CREEK, RISKE'S CROSSING - DIRT ROAD ADJACENT TO EAST SIDE OF REGINA
LAGOON - SAMPLE DOWNSTREAM SIDE OF BRIDGE AT MIDSTREAM

SAMPLE DATE D	H	CST Y	HR	SUBM ID	36002L COLIFORMS TOTAL MF NO/100ML	36012L COLIFORMS FECAL MF NO/100ML	36102L STREP. FECAL MF NO/100ML	36001L COLIFORMS TOTAL MPN NO/100ML	36000L COLIFORMS TOTAL MPN NO/ML	36011L COLIFORMS FECAL MPN NO/100ML	36010L COLIFORMS FECAL MPN NO/ML
23	OA	A2	0832	A001		560.	710.	4300.		4300.	70.
24	OA	A2	0840	A001	5000.	52.	48.	930.			
28	OA	A2	0842	A001	3000.	80.	72.	4300.		L30.	
30	OA	A2	0950	A001	900.	16.					
31	OA	A2	0920	A001	3000.	28.	68.	40.		L30.	

PARAMETER VALUE CODES

E...ESTIMATED VALUE
H...EXCEEDS VALIDATION LIMITS
K...INSUFFICIENT SAMPLE
N...INTERFERENCE
P...RESULT QUESTIONABLE AND POOR BLANK DEPLETION
Q...RESULT QUESTIONABLE
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W...INACCURATE RESULTS DUE TO SAMPLE AGE
X...NOT COMPLETED DUE TO LACK OF LABORATORY CAPACITY
Y...VERIFIED RESULT
Z...MACHINE MALFUNCTION

EQUIDAT DETAILED REPORT

STATION 7598[illegible]0001 LAT. 50D 28M 40S LONG. 104D 45M 53 PR S UTM 00 395400E 5592600N

REGINA SEWAGE FINAL EFFLUENT ADVANCED WATEWATER TREATMENT

SAMPLE DATE CST D	M	Y	HR	STORM TD	36002L COLIFORMS TOTAL MF NO/100ML	36012L COLIFORMS FECAL MF NO/100ML	36102L STREP. FECAL MF NO/100ML	36001L COLIFORMS TOTAL MPN NO/100ML	36000L COLIFORMS TOTAL MPN NO/ML	36011L COLIFORMS FECAL MPN NO/100ML	36010L COLIFORMS FECAL MPN NO/ML
05	07	82	0920	A001	1000.	L100.	L100.	1200.		L23.	
05	07	82	0925	A001	3000.	L100.	L100.	430.		40.	
06	07	82	1240	A001				40.		40.	
06	07	82	1245	A001				110.		L23.	
12	07	82	0905	9999	3000.	90.	L10.	230.		L23.	
13	07	82	0900	9999	G30000.	G3000.	520.		G23000.		G23000.
19	07	82	0850	A001	1000.	310.	L10.	43000.		2000.	
20	07	82	0910	A001	L100.	L10.	L10.	L23.		L23.	
26	07	82	0837	A001	04400.	220.	220.	2100.		750.	
27	07	82	0830	A001	N	N	200.	93000.		43000.	
03	08	82	1105	A001	L10.	L4.	L10.	L30.		L30.	
03	08	82	1110	A001	L4.	L2.	L2.	L30.		L30.	
03	08	82	1510	A001	110.	L4.	L4.	L30.		L30.	
03	08	82	2010	A001	110.	L4.	L4.	L30.		L30.	
04	08	82	0910	A001	40.	110.	L10.	90.		L30.	
04	08	82	0912	A001	20.	L4.	L4.	90.		L30.	
09	08	82	0900	A001	47000.	1200.	160.	23000.		2400.	
09	08	82	0902	A001		50.	550.	93000.		40.	
09	08	82	1505	A001	L10.	L4.	L4.	40.		40.	
09	08	82	1930	A001	20.	L4.	L4.	40.		L30.	
10	08	82	1025	A001	82000.	2000.	1000.	93000.		23000.	
10	08	82	1027	A001		1000.	690.	240000.		9300.	
10	08	82	1400	A001		12.	L4.	9300.		70.	
10	08	82	1945	A001	900.	L4.	L4.	2400.		L30.	
16	08	82	0855	A001	01400.	56.	100.	9300.		230.	
17	08	82	0845	A001	F2600.	700.	240.	23000.		4600.	
23	08	82	0900	A001	110.	L4.	L4.	40.		L30.	
23	08	82	0902	A001	110.	L4.	L4.	L30.		L30.	
24	08	82	0845	A001	110.	L4.	L4.	L30.		L30.	
24	08	82	0847	A001	110.	L4.	L4.	L30.		L30.	
30	08	82	0943	A001	26000.	570.					
31	08	82	0835	A001	L100.	L10.	L4.	L30.		L30.	

PARAMETER VALUE CODES

I...ESTIMATED VALUE
K...EXCEEDS VALIDATION LIMITS
N...INSUFFICIENT SAMPLE
O...INTERFERENCE
P...RESULT QUESTIONABLE AND POOR BLANK DEPLETION
Q...RESULT QUESTIONABLE
R...POOR DEPLETION IN THE BLANK
S...LABORATORY ACCIDENT
T...SAMPLE CONTAINER BROKEN IN TRANSIT
U...RESULTS APPEAR ERRONEOUS
9999....DATA NOT VERIFIED
V...SUSPECTED SAMPLE CONTAMINATION
W...INACCURATE RESULTS DUE TO SAMPLE AGE
X...NOT COMPLETED DUE TO LACK OF LABORATORY CAPACITY
Y...VERIFIED RESULT
Z...MACHINE MALFUNCTION

ESQUADAT DETAILED REPORT

STATION 08RK051S0004 LAT. 50D 29M 1S LONG. 104D 46M 43S PR 3 UTM 00 395150E 5593200N

MASCANA CREEK, ST^MAR CROSSING DOWNSTREAM SIDE OF BRIDGE AT MIDSTREAM

SAMPLE DATE (CST) D	M	Y	HR	SOURCE ID	36002L COLIFORMS TOTAL MF NO/100ML	36012L COLIFORMS FECAL MF NO/100ML	36102L STREP. FECAL MF NO/100ML	36001L COLIFORMS TOTAL MPN NO/100ML	36000L COLIFORMS TOTAL MPN NO/ML	36011L COLIFORMS FECAL MPN NO/100ML	36010L COLIFORMS FECAL MPN NO/ML
05	07	82	0915	R001	4400.	110.	L10.	4600.		150.	
05	07	82	0940	R001	2700.	110.	10.	23000.		750.	
06	07	82	1250	R001	9000.	130.	80.	4600.		200.	
06	07	82	1255	R001	7400.	120.	210.	750.		230.	
12	07	82	0930	9999	30000.	260.	200.	9300.		230.	
12	07	82	0935	9999	9000.	650.	410.	4300.		430.	
13	07	82	0915	9999	6500.	170.	140.	4300.		930.	
19	07	82	0910	R001	200.	130.	30.	11000.		930.	
20	07	82	0930	R001	G10000.	600.	410.	7500.		230.	
26	07	82	0900	R001	Q45000.	G200.	240.	4300.		150.	
26	07	82	1515	R001	Q12000.	310.	230.	7500.		40.	
26	07	82	1945	R001	Q21000.	280.	500.	1500.		90.	
27	07	82	0945	R001	12000.	30.	280.	4300.		90.	
27	07	82	1515	R001	5000.	300.	230.	4300.		40.	
27	07	82	2000	R001	9000.	110.	260.	1500.		L30.	
03	08	82	1120	R001	Q2600.	48.	96.	430.		70.	
03	08	82	1520	R001	19000.	50.	150.	2400.		70.	
03	08	82	1525	R001	4000.	80.	140.	4600.		150.	
03	08	82	2030	R001	13000.	60.	92.	2400.		70.	
04	08	82	0940	R001	5000.	28.	290.	2400.		236.	
04	08	82	0942	R001	19000.	48.	250.			40.	
04	08	82	0945							L30.	
09	08	82	0925	R001		50.	210.	460000.		1500.	
09	08	82	0927	R001	48000.	1630.	120.	23000.		430.	
09	08	82	1525	R001	Q45000.	10.	420.	23000.			
09	08	82	1950	R001	28000.	4.	120.	24000.		L30.	
10	08	82	1050	R001	31000.	8.	380.	1500.		46.	
10	08	82	1052	R001		Q80.	500.	7500.		40.	
10	08	82	1610	R001		180.	150.	9300.		430.	
10	08	82	2000	R001	Q30000.	24.	124.	21000.		210.	
16	08	82	0920	R001	8000.	12.	G400.	4300.		L30.	
17	08	82	0903	R001	11000.	8.	G800.	930.		L30.	

PARAMETER VALUE CODES

E...ESTIMATED VALUE
K...EXCEEDS VALIDATION LIMITS
K...INSUFFICIENT SAMPLE
N...INTERFERENCE
P...RESULT QUESTIONABLE AND POOR BLANK DEPLETION
Q...RESULT QUESTIONABLE
R...POOR DEPLETION IN THE BLANK
S...LABORATORY ACCIDENT
T...SAMPLE CONTAINER BROKEN IN TRANSIT
U...RESULTS APPEAR ERRONEOUS
9999....DATA NOT VERIFIED
V...SUSPECTED SAMPLE CONTAMINATION
W...INACCURATE RESULTS DUE TO SAMPLE AGE
X...NOT COMPLETED DUE TO LACK OF LABORATORY CAPACITY
Y...VERIFIED RESULT
Z...MACHINE MALFUNCTION

ESQUADAT DETAILED REPORT

STATION 05K05S13000A LAT. 50D 29M 18 LONG. 104D 46M 43S PR 3 UTM 00 395150E 5593200N

WASCANA CREEK, STONE BRIDGE CROSSING DOWNSTREAM SIDE OF BRIDGE AT MIDSTREAM

SAMPLE DATE CST D	M	Y	HR	SUBM TD	36002L COLIFORMS TOTAL MF NO/100ML	36012L COLIFORMS FECAL MF NO/100ML	36102L STREP. FECAL MF NO/100ML	36001L COLIFORMS TOTAL MPN NO/100ML	36000L COLIFORMS TOTAL MPN NO/ML	36011L COLIFORMS FECAL MPN NO/100ML	36010L COLIFORMS FECAL MPN NO/ML
23	08	82	0920	A001		70.	120.	23000.		40.	
23	08	82	0922	A001		64.	130.	43000.		<30.	
24	08	82	0910	A001	0110.	8.	36.	930.		<30.	
24	08	82	0912	A001	0500.	4.	32.	1500.		<30.	
30	08	82	1000	A001	6000.	16.					
31	08	82	0850	A001	03000.	12.	60.	930.		90.	

PARAMETER VALUE CODES

E...ESTIMATED VALUE
H...EXCEEDS VALIDATION LIMITS
K...INSUFFICIENT SAMPLE
N...INTERFERENCE
P...RESULT QUESTIONABLE AND POOR BLANK DEPLETION
Q...RESULT QUESTIONABLE
R...POOR DEPLETION IN THE BLANK
S...LABORATORY ACCIDENT
T...SAMPLE CONTAINER BROKEN IN TRANSIT
U...RESULTS APPEAR ERRONEOUS
9444....DATA NOT VERIFIED
V...SUSPECTED SAMPLE CONTAMINATION
W...INACCURATE RESULTS DUE TO SAMPLE AGE
X...NOT COMPLETED DUE TO LACK OF LABORATORY CAPACITY
Y...VERIFIED RESULT
Z...MACHINE MALFUNCTION

ESQUADAT DETAILED REPORT

STATION 06SK05130005 LAT. 50D 29M 59S LONG. 104D 47M 59S PR 3 UTM 00 395050E 5595000N

MASCANA CREEK, HUNGRY HOLLOW; JUST LEFT SIDE FACING DOWNSTREAM; ABOVE SHERWOOD FOREST PARK; SAMPLE 1/3 DOWNSTREAM SIDE OF BRIDGE

SAMPLE DATE D	M	CST Y	HR	SURM ID	36002L COLIFORMS TOTAL MF NO/100ML	36012L COLIFORMS FECAL MF NO/100ML	36102L STREP. FECAL MF NO/100ML	36001L COLIFORMS TOTAL MPN NO/100ML	36000L COLIFORMS TOTAL MPN NO/ML	36011L COLIFORMS FECAL MPN NO/100ML	36010L COLIFORMS FECAL MPN NO/ML
12	07	82	1600	9999				2300.		90.	
26	07	82	0945	A001	1600.	90.	160.	430.		230.	
26	07	82	0825	A001	Q7400.	Q290.	190.	4300.		4300.	
27	07	82	0910	A001	Q4700.	260.	310.	9300.		230.	
03	08	82	1125	A001	Q2200.	60.	100.	750.		150.	
04	08	82	1000	A001		72.	68.	930.		L30.	
09	08	82	0950	A001	E4600.	60.	40.	430.		L30.	
10	08	82	1105	A001	Q1700.	10.	80.	930.		90.	

PARAMETER VALUE CODES

E...ESTIMATED VALUE
H...EXCEEDS VALIDATION LIMITS
K...INSUFFICIENT SAMPLE
N...INTERFERENCE
P...RESULT QUESTIONABLE AND POOR BLANK DEPLETION
Q...RESULT QUESTIONABLE
R...POOR DEPLETION IN THE BLANK
S...LABORATORY ACCIDENT
T...SAMPLE CONTAINER BROKEN IN TRANSIT
U...RESULTS APPEAR ERRONEOUS
9999....DATA NOT VERIFIED
V...SUSPECTED SAMPLE CONTAMINATION
W...INACCURATE RESULTS DUE TO SAMPLE AGE
X...NOT COMPLETED DUE TO LACK OF LABORATORY CAPACITY
Y...VERIFIED RESULT
Z...MACHINE MALFUNCTION

ESQUADAT DETAILED REPORT

STATION 08SB05130002 LAT. 33D 31M 14S LONG. 104D 51M 28 PR 1 UTM 00 394750E 5597350N

MASCANA CREEK, OLD CROSSING; SAMPLE APPROX. 100 YARDS UPSTREAM OF NEW
BRIDGE (INSTALLED IN 1975); RIGHT BANK IN SUMMER, MIDSTREAM IN WINTER

SAMPLE DATE D	M	Y	HR CST	SOURCE CD	36002L COLIFORMS TOTAL MF NO/100ML	36012L COLIFORMS FECAL MF NO/100ML	36102L STREP. FECAL MF NO/100ML	36001L COLIFORMS TOTAL MPN NO/100ML	36000L COLIFORMS TOTAL MPN NO/ML	36011L COLIFORMS FECAL MPN NO/100ML	36010L COLIFORMS FECAL MPN NO/ML
12	07	82	1015	9999				4300.		230.	

PARAMETER VALUE CODES

E...ESTIMATED VALUE
H...EXCEEDS VALIDATION LIMITS
K...INSUFFICIENT SAMPLE
N...INTERFERENCE
P...RESULT QUESTIONABLE AND POOR BLANK DEPLETION
Q...RESULT QUESTIONABLE
R...POOR DEPLETION IN THE BLANK
S...LABORATORY ACCIDENT
T...SAMPLE CONTAINER BROKEN IN TRANSIT
U...RESULTS APPEAR ERRONEOUS
9999....DATA NOT VERIFIED
V...SUSPECTED SAMPLE CONTAMINATION
W...INACCURATE RESULTS DUE TO SAMPLE AGE
X...NOT COMPLETED DUE TO LACK OF LABORATORY CAPACITY
Y...VERIFIED RESULT
Z...MACHINE MALFUNCTION

ESQUADAT DETAILED REPORT

STATION 09SK051300001 LAT. 50D 34M 22S LONG. 104D 50M 5S PR 3 UTM 00 394950E 5603150N

WASCANA CREEK, SATTERED BRIDGE UPSTREAM SIDE OF BRIDGE AT MID-RIVER

SAMPLE DATE CST D M Y HR	SURM ID	36002L COLIFORMS TOTAL MF NO/100ML	36012L COLIFORMS FECAL MF NO/100ML	36102L STREP. FECAL MF NO/100ML	36001L COLIFORMS TOTAL MPN NO/100ML	36000L COLIFORMS TOTAL MPN NO/ML	36011L COLIFORMS FECAL MPN NO/100ML	36010L COLIFORMS FECAL MPN NO/ML
08 07 82 1230	0001	60.	35.	7.				
12 07 82 1010	9999				2300.		40.	

PARAMETER VALUE CODES

E...ESTIMATED VALUE
H...EXCEEDS VALIDATION LIMITS
K...INSUFFICIENT SAMPLE
N...INTERFERENCE
P...RESULT QUESTIONABLE AND POOR BLANK DEPLETION
Q...RESULT QUESTIONABLE
R...POOR DEPLETION IN THE BLANK
S...LABORATORY ACCIDENT
T...SAMPLE CONTAINER BROKEN IN TRANSIT
U...RESULTS APPEAR ERRONEOUS
9999....DATA NOT VERIFIED
V...SUSPECTED SAMPLE CONTAMINATION
W...INACCURATE RESULTS DUE TO SAMPLE AGE
X...NOT COMPLETED DUE TO LACK OF LABORATORY CAPACITY
Y...VERIFIED RESULT
Z...MACHINE MALFUNCTION

ESQUADAT DETAILED REPORT

STATION 05SK0S1S0008 LAT. 50D 38M 9S LONG. 104D 54M 34S PR 3 UTM 00 394A00E 5610150N

WASCANA CREEK, ARUVE QU'APPELLE RIVER DRAIN, DOWNSTREAM OF ROCK WEIR OR AS A ROAD; 1 1/2 MILES WEST OF LUMSDEN ON GRID SECOND PRIORITY AT MID-RIVER AT THE

SAMPLE DATE D	M	CST Y	HR	SUBM ID	36002L COLIFORMS TOTAL MF NO/100ML	36012L COLIFORMS FECAL MF NO/100ML	36102L STREP. FECAL MF NO/100ML	36001L COLIFORMS TOTAL MPN NO/100ML	36000L COLIFORMS TOTAL MPN NO/ML	36011L COLIFORMS FECAL MPN NO/100ML	36010L COLIFORMS FECAL MPN NO/ML
12	07	82	1100	9999	500.	20.	90.				
20	07	82	1030	A001	200.	50.	160.	750.		90.	
26	07	82	1030	A001	G1900.	G190.	G180.	9300.			
27	07	82	0940	A001	2400.	140.	266.	2300.		90.	
03	08	82	1145	A001	800.	42.	060.	2400.		90.	
04	08	82	1030	A001	3000.	200.	108.	930.		430.	
09	08	82	1025	A001	3900.	54.	120.	2300.		70.	
10	08	82	1145	A001	1400.	14.	82.	4300.		40.	

PARAMETER VALUE CODES

L...ESTIMATED VALUE
N...EXCEEDS VALIDATION LIMITS
K...INSUFFICIENT SAMPLE
N...INTERFERENCE
P...RESULT QUESTIONABLE AND POOR BLANK DEPLETION
Q...RESULT QUESTIONABLE
R...POOR DEPLETION IN THE BLANK
S...LABORATORY ACCIDENT
T...SAMPLE CONTAINER BROKEN IN TRANSIT
U...RESULTS APPEAR ERRONEOUS
9999....DATA NOT VERIFIED
V...SUSPECTED SAMPLE CONTAMINATION
W...INACCURATE RESULTS DUE TO SAMPLE AGE
X...NOT COMPLETED DUE TO LACK OF LABORATORY CAPACITY
Y...VERIFIED RESULT
Z...MACHINE MALFUNCTION

ESQUADAT DETAILED REPORT

STATION 08SB05150001 LAT. 50D 38M 58 LONG. 104D 56M 21S PR 3 UTM 00 394350E 5610050N

QU'APPELLE RIVER, ABOVE WASCANA CREEK; AND 300 METERS NORTH ON DIRT ROAD; 3 MILES WEST OF LUMSDEN ON GRID ROAD DOWNSTREAM SIDE OF BRIDGE AT MIDSTREAM

SAMPLE DATE D	M	CST Y	HR	SUBM ID	36002L COLIFORMS TOTAL MF NO/100ML	36012L COLIFORMS FECAL MF NO/100ML	36102L STREP. FECAL MF NO/100ML	36001L COLIFORMS TOTAL MPN NO/100ML	36000L COLIFORMS TOTAL MPN NO/ML	36011L COLIFORMS FECAL MPN NO/100ML	36010L COLIFORMS FECAL MPN NO/ML
12	07	82	1110	9999	200.	L10.	30.	230.		40.	
28	07	82	1100	A001	100.	10.	90.	430.		750.	
26	07	82	1015	A001	1800.	950.	930.	1500.		430.	
27	07	82	1010	A001	24300.	2430.	360.	930.		430.	
03	08	82	1150	A001	22200.	210.	190.			390.	
04	08	82	1050	A001	6000.	220.	130.	390.		90.	
09	08	82	1057	A001	2100.	80.	60.	230.		40.	
10	08	82	1200	A001	2400.	20.	30.	230.			
30	08	82	1000	A001	800.	28.					

PARAMETER VALUE CODES

E...ESTIMATED VALUE
H...EXCEEDS VALIDATION LIMITS
K...INSUFFICIENT SAMPLE
N...INTERFERENCE
P...RESULT QUESTIONABLE AND POOR BLANK DEPLETION
Q...RESULT QUESTIONABLE
R...POOR DEPLETION IN THE BLANK
S...LABORATORY ACCIDENT
T...SAMPLE CONTAINER BROKEN IN TRANSIT
U...RESULTS APPEAR ERRONEOUS
9999...DATA NOT VERIFIED
V...SUSPECTED SAMPLE CONTAMINATION
W...INACCURATE RESULTS DUE TO SAMPLE AGE
X...NOT COMPLETED DUE TO LACK OF LABORATORY CAPACITY
Y...VERIFIED RESULT
Z...MACHINE MALFUNCTION

STATION 05SK05150005 LAT. 50D 39M 16S LONG. 104D 51M 58 PR 3 UTM 13 3950006 5612250N

QU'APPELLE RIVER, NO.11 HIGHWAY AT MIDSTREAM. DOWNSTREAM SIDE OF WEST BOUND BRIDGE

SAMPLE DATE D M Y	CST HR	SURM TD	36002L COLIFORMS TOTAL MF NO/100ML	36012L COLIFORMS FECAL MF NO/100ML	36102L STREP. FECAL MF NO/100ML	36001L COLIFORMS TOTAL MPN NO/100ML	36000L COLIFORMS TOTAL MPN NO/ML	36011L COLIFORMS FECAL MPN NO/100ML	36010L COLIFORMS FECAL MPN NO/ML
12 07 82	1130	9999	700.	10.	90.				
20 07 82	1115	A001	2100.	80.	100.	11000.		230.	
26 07 82	1035	A001	03000.	670.	980.	9300.		1500.	
27 07 82	1010	A001	04500.	580.	A90.	2300.		2300.	
03 08 82	1245	A001	2000.	120.	10.	S		S	
08 08 82	1110	A001	5000.	100.	210.	930.		150.	
09 08 82	1055	A001	2000.	64.	120.	230.		40.	
10 08 82	1215	A001	1700.	32.	150.	930.		40.	
30 08 82	1055	A001	3A00.	A.					

PARAMETER VALUE CODES

E...ESTIMATED VALUE
K...EXCEEDS VALIDATION LIMITS
I...INSUFFICIENT SAMPLE
N...INTERFERENCE
P...RESULT QUESTIONABLE AND POOR BLANK DEPLETION
Q...RESULT QUESTIONABLE
R...POOR DEPLETION IN THE BLANK
S...LABORATORY ACCIDENT
T...SAMPLE CONTAINER BROKEN IN TRANSIT
U...RESULTS APPEAR ERRONEOUS
9999....DATA NOT VERIFIED
V...SUSPECTED SAMPLE CONTAMINATION
W...INACCURATE RESULTS DUE TO SAMPLE AGE
X...NOT COMPLETED DUE TO LACK OF LABORATORY CAPACITY
Y...VERIFIED RESULT
Z...MACHINE MALFUNCTION

STATION 0050605150009 LAT. 50D 41M 55S LONG. 104D 48M 11S PR 3 UTM 0U 395450E 5617100N

QU'APPELLE RIVER, MARKET GARDENS; DOWNSTREAM SIDE OF ROAD BRIDGE AT MIDSTREAM

SAMPLE DATE CST				SUBM ID	36002L COLIFORMS TOTAL MF NO/100ML	36012L COLIFORMS FECAL MF NO/100ML	36102L STREP. FECAL MF NO/100ML	36001L COLIFORMS TOTAL MPN NO/100ML	36000L COLIFORMS TOTAL MPN NO/ML	36011L COLIFORMS FECAL MPN NO/100ML	36010L COLIFORMS FECAL MPN NO/ML
D	M	Y	HR								
12	07	82	1150	9999	100.	110.	L10.				
20	07	82	1140	8001	100.	20.	130.	430.		40.	
26	07	82	1100	8001	1600.	40.	160.	2300.		L30.	
26	07	82	1102	8001				430.		40.	
26	07	82	1105	8001	500.	100.	180.	430.		L23.	
26	07	82	1610	8001	8500.	50.	180.	230.		90.	
26	07	82	2045	8001	8900.	60.	200.	230.			
27	07	82	1040	8001	700.	300.	340.	930.		430.	
27	07	82	1600	8001	500.	210.	132.	430.		70.	
27	07	82	2045	8001	1200.	60.	190.	2300.		L30.	
03	08	82	1215	8001	500.	80.	40.	430.		150.	
03	08	82	1220	8001	200.	20.	40.	90.		90.	
03	08	82	1545	8001	900.	110.	190.	390.		40.	
03	08	82	2100	8001	1400.	40.	220.	230.		230.	
08	08	82	1110	8001	900.	20.	100.	2400.		90.	
09	08	82	1132	8001	1400.	32.	132.	2100.		200.	
09	08	82	1115	8001	3700.	20.	60.	90.		L30.	
09	08	82	1117	8001	5000.	110.	70.	90.		L30.	
09	08	82	1615	8001	1300.	L10.	40.	140.		40.	
09	08	82	2045	8001	1000.	8.	36.	430.		L30.	
10	08	82	1230	8001	700.	36.	40.	230.		L30.	
10	08	82	1252	8001	2100.	10.	36.	230.		L30.	
10	08	82	1720	8001	1000.	8.	8.	90.		L30.	
10	08	82	2045	8001	11000.	8.	8.	40.		L30.	
30	08	82	1110	8001	900.	8.	40.				

PARAMETER VALUE CODES

E...ESTIMATED VALUE
H...EXCEEDS VALIDATION LIMITS
K...INSUFFICIENT SAMPLE
N...INTERFERENCE
P...RESULT QUESTIONABLE AND POOR PLANK DEPLETION
Q...RESULT QUESTIONABLE
R...POOR DEPLETION IN THE BLANK
S...LABORATORY ACCIDENT
T...SAMPLE CONTAINER BROKEN IN TRANSIT
U...RESULTS APPEAR ERRONEOUS
9999....DATA NOT VERIFIED
V...SUSPECTED SAMPLE CONTAMINATION
W...INACCURATE RESULTS DUE TO SAMPLE AGE
X...NOT COMPLETED DUE TO LACK OF LABORATORY CAPACITY
Y...VERIFIED RESULT
Z...MACHINE MALFUNCTION

Appendix 3

CURRENT CONDITIONS ON THE APPROVAL TO OPERATE THE REGINA TERTIARY TREATMENT PLANT

Province of Saskatchewan

DEPARTMENT OF THE ENVIRONMENT

Certificate No. 1256

CERTIFICATE OF APPROVAL TO OPERATE

Issued Under the Authority of The Water Resources Management Act

The operation of the sanitary sewage works approved for construction by the department, the saskatchewan water resources commission or a minister of the Crown for the CITY of REGINA may be carried out subject to the term and conditions stated below.

Term of Approval to August 1, 1984

Conditions of Approval

1. Unless otherwise approved, the phytoplankton (algae) concentration (as measured by chlorophyll-a) in the effluent discharged to Wascana Creek shall not exceed 80 micrograms/litre based on a five consecutive sample average.

2. Unless otherwise approved, the phosphorus concentration as measured by total phosphorus, in the effluent discharged to Wascana Creek shall not exceed 1.0 milligrams/litre based on any weekly average.

3. Unless otherwise approved, the sewage effluent shall be disinfected during the period May 15 to September 20 in such a manner to achieve a total chlorine residual of 0.5 mg/L after 15 minutes contact time or alternatively to ensure that the water in Wascana Creek near SW 11-18-21-W2 does not contain more than 5,000 total coliforms per 100 mL nor 1,000 fecal coliforms per 100 mL during this period.

4. Unless otherwise approved, the effluent shall have a pH within the range 6.0 to 9.0 with a deviation of ± 1.0 unit not to exceed 3 consecutive days duration.

5. The facility shall be operated in such a manner to minimize release of chemical precipitates in the effluent.

6. The City shall maintain the following records using, where applicable, analytical and sampling procedures approved by the Department and such information shall be submitted to the Department monthly.

   (a) The volume of effluent measured daily;

   (b) The chlorophyll-a concentration of the final effluent measured three days a week during the months of May through October, or as otherwise approved by the Department;

Dated at Regina, Saskatchewan, this Nineteenth day of August A.D. 1981

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Department of the Environment

Approved

Deputy Minister
Department of the Environment

WPC-3 MAY. 1972

(c) The total phosphorus concentration of the final effluent measured on at least five days every week;

(d) The pH of the final effluent measured daily;

(e) The suspended solids concentration of the final effluent measured on at least three days every week;

(f) The 5-day 20°C Biochemical Oxygen Demand of final effluent measured on at least three days every week;

(g) The total and fecal coliform count of dechlorinated final effluent or of Wascana Creek near SW 11-18-21-W2 measured weekly.

7. The City shall determine or cause to be determined other analytical or operating information respecting the sewage treatment facilities as from time-to-time may be requested by the Department.

8. Any alteration to the normal operation of the facilities which may result in abnormal effluent discharge with respect to quality or quantity shall not be undertaken without prior notification to the Department.

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